DECLARATION

I, Nobuaki Kato, a Japanese Patent Attorney registered No. 8517, of Okabe International Patent Office at No. 602, Fuji Bldg., 2-3, Marunouchi 3-chome, Chiyoda-ku, Tokyo, Japan, hereby declare that I have a thorough knowledge of Japanese and English languages, and that the attached pages contain a correct translation into English of the priority documents of Japanese Patent Application No. 2000-280505 filed on September 14, 2000 in the name of CANON KABUSHIKI KAISHA.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made, are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

signed this 14th day of March 2005

NOBUAKI KATO

PATENT OFFICE
JAPANESE GOVERNMENT

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[Title of the Invention] METHOD OF PRODUCING ELECTROCONDUCTIVE FILM, CIRCUIT SUBSTRATE, ELECTRON SOURCE, AND IMAGE FORMING APPARATUS, AND THE ELECTROCONDUCTIVE FILM, THE CIRCUIT SUBSTRATE, THE ELECTRON SOURCE, AND THE IMAGE FORMING APPARATUS

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[Name of Document] SPECIFICATION

[Title of the Invention] METHOD OF PRODUCING ELECTROCONDUCTIVE FILM, CIRCUIT SUBSTRATE, ELECTRON SOURCE, AND IMAGE FORMING APPARATUS, AND THE ELECTROCONDUCTIVE FILM, THE CIRCUIT SUBSTRATE, THE ELECTRON SOURCE, AND THE IMAGE FORMING APPARATUS

[Claims]

[Claim 1] A method of producing an electroconductive film, comprising:

a film-forming step of forming a film containing a photosensitive material and an electroconductive material on a substrate;

an exposure step of irradiating a light on a desired region of the film formed in the film-forming step, at least two times to form a latent image of the film;

a developing step of removing the non-latent image region of the film after the exposure step to form a developed image; and

a baking step of baking the developed image formed in the developing step.

[Claim 2] A method of producing an electroconductive film according to Claim 1, wherein in the exposure step, a light is irradiated at the second time and the succeeding time to form a latent image having a different size from that of the latent image formed by irradiation at the first time.

[Claim 3] A method of producing an electroconductive film, comprising:

a laminate-film forming step of repeating a film-forming step of forming a film containing a photosensitive material and an electroconductive material on a substrate and an exposure step of irradiating a light on a desired region of the film formed in the film-forming step, sequentially at least two times, whereby the formed films are laminated, and thus, the latent images of the respective layers are integrated to form a laminate latent image;

a developing step of removing the non-latent image regions in the laminate film at one time after the laminate film is formed, to form a developed image; and

a baking step of baking the developed image formed in the developing step.

[Claim 4] A method of producing an electroconductive film according to Claim 3, wherein in the laminate-film forming step, each latent image of the second layer and a succeeding layer is formed so as to have a size different from that of the latent image of the first layer on the substrate.

[Claim 5] A method of producing an electroconductive film according to Claim 2 or 4, wherein in the exposure step, the opening portion of the mask having an opening portion for irradiating a light onto a desired region of the film is changed, whereby the latent images having different sizes

are formed.

[Claim 6] A method of producing an electroconductive film according to Claim 2 or 4, wherein in the exposure step, the interval between the mask having an opening portion for irradiating a light onto a desired region of the film and the film is changed at irradiation of a light, whereby the latent images having different sizes are formed.

[Claim 7] A method of producing an electroconductive film according to any one of Claims 1 to 6, wherein the electroconductive material is a metal.

[Claim 8] A method of producing an electroconductive film according to any one of Claims 1 to 6, wherein the electroconductive material comprises electroconductive grains.

[Claim 9] A method of producing an electroconductive film according to any one of Claims 1 to 8, wherein the film-thickness after the baking step is not less than 5 μm.

[Claim 10] A method of producing a circuit substrate having a wiring, wherein the wiring is formed by the method of producing an electroconductive film defined in any one of Claims 1 to 9.

[Claim 11] A method of producing an electron source having a wiring and an electron-emitting device capable of being driven when an electric current is supplied to the wiring, wherein the wiring is formed by the method of

producing an electroconductive film defined in any one of Claims 1 to 9.

[Claim 12] A method of producing an image forming apparatus having an electron source and an image forming member capable of forming an image by means of an electron emitted from the electron source, wherein the electron source is formed by the method of producing an electron source defined in Claim 11.

[Claim 13] An electroconductive film produced by the method of producing an electroconductive film defined in any one of Claims 1 to 9.

[Claim 14] A circuit substrate including a wiring using the electroconductive film defined in Claim 13.

[Claim 15] An electron source comprising

a wiring using the electroconductive film defined in Claim 13, and

an electron-emitting device capable of being driven when an electric current is supplied to the wiring.

[Claim 16] An image forming apparatus comprising

an electron source defined in Claim 15, and

an image forming member capable of forming an image by means of an electron emitted from the electron source.

[Claim 17] A method of producing an electroconductive film, comprising:

(A) a film-forming step of forming a film containing a

photosensitive material and an electroconductive material on a substrate;

(B) an exposure step of irradiating a light on a desired region of the film formed in the film-forming step and containing the photosensitive and the electroconductive material, at least two times;

(C) a developing step of removing the non-exposed region or the exposed region of the film having an exposed region exposed in the exposure step and a non-exposed region;

(D) a baking step of baking the film after the film is subjected to the developing step.

[Claim 18] A method of producing an electroconductive film, comprising:

a laminate-film forming step of repeating

(A) a film-forming step of forming a film containing a photosensitive material and an electroconductive material on a substrate, and

(B) an exposure step of irradiating a light on a desired region of the film formed in the film-forming step, sequentially at least two times, whereby the plural films each containing an exposed region and a non-exposed region are laminated to form a laminate film;

(C) a developing step of removing the non-exposed region or the exposed region in the laminate film; and

(D) a baking step of baking the laminate film after the film is subjected to the developing step.

[Claim 19] A method of producing an electroconductive film according to Claim 17 or 18, wherein in the film-forming step, a paste containing the photosensitive material and the electroconductive material is coated onto the substrate.

[Claim 20] A method of producing an electroconductive film according to Claim 17, 18 or 19, wherein the electroconductive material is a metal.

[Claim 21] A method of producing an electroconductive film according to Claim 17, 18, or 19, wherein the electroconductive material comprises electroconductive grains.

[Claim 22] An electroconductive film produced by the method of producing an electroconductive film defined in any one of Claims 17 to 21.

[Claim 23] An electroconductive film according to Claim 22, wherein the film-thickness is not less than 5 μm.

[Claim 24] A circuit substrate having a wiring, wherein the electroconductive film defined in Claim 22 or 23 is used as a wiring.

[Claim 25] An electron source having an electron-emitting device formed on a substrate and a wiring for driving the electron-emitting device, wherein the electroconductive film

defined in Claim 22 or 23 is used as a wiring.

[Claim 26] An image forming apparatus comprising

the electron source defined in Claim 25, and

an image forming member.

[Claim 27] A method of producing a circuit substrate having a wiring formed of an electroconductive film, wherein the electroconductive film is formed by the method of producing an electroconductive film defined in any one of Claims 17 to 21.

[Claim 28] A method of producing an electron source having an electron-emitting device formed on a substrate and a wiring formed of an electroconductive film for driving the electron-emitting device, wherein the electroconductive film is formed by the method of producing an electroconductive film defined in any one of Claims 17 to 21.

[Claim 29] A method of producing an image forming apparatus having an electron source and an image forming member, wherein the electron source is formed by the method of producing an electron source defined in Claim 28.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to methods of manufacturing an electroconductive film, a circuit substrate, an electron source, and an image forming apparatus, and the

electroconductive film, the circuit substrate, the electron source, and the image forming apparatus, each using, e.g., a photosensitive paste.

[0002]

[Description of the Related Art]

A conventional surface conduction electron-emitting device is shown in Fig. 13. Fig. 13(a) is a schematic plane view showing a conventional electron-emitting device. Fig. 13(b) is a schematic cross-sectional view taking along a line B-B in Fig. 13(a).

[0003]

Referring to Fig. 13, reference numeral 11 denotes an insulating substrate, 7 denotes an electron emission electroconductive film, 2 and 3 denote electrodes, and 8 denotes an electron-emitting portion.

[0004]

Fig. 14 is a schematic structural view showing an example of an image display device such as an image-forming apparatus using the electron-emitting device such as the surface conduction electron-emission device shown in the above-mentioned Fig. 13.

[0005]

In Fig. 14, reference numeral 81 denotes a substrate, 82 denotes an outer frame, and 86 denotes a face plate in which an image forming member 84 is disposed. The

respective connecting portions of the outer frame 82, the substrate 81, and the face plate 86 are sealed with an adhesive such as a low melting point glass frit (not shown) to structure an envelope (air tight vessel) 88 for maintaining the interior of the image display device in a vacuum state.

[0006]

A substrate 11 is fixed on the substrate 81. On the substrate 11 are arranged n × m electron-emitting devices 74 (n and m are positive integers of 2 or more and appropriately set in accordance with the number of target display pixels).

[0007]

Also, the respective electron-emitting devices 74 are connected to wirings 4 and 6 formed of electroconductive films. The wirings in Fig. 14 comprises m column-directional wirings 6 and n row-directional wirings 4 (also called "matrix wiring"). An insulating layer (not shown) is disposed on each cross portion of the row-directional wirings 4 and the column-directional wirings 6 to insulate the row-directional wirings 4 and the column-directional wirings 6 from each other.

[0008]

In formation of the above image device, it is necessary to form a large number of row-directional wirings 4 and

column-directional wirings 6.

[0009]

A method of arranging and forming a large number of row-directional wirings 4 and column-directional wirings 6 is disclosed in Japanese Patent Application Laid-open No. 8-34110 and so forth. According to this method, wirings formed of electrostatic films are formed in a printing technique which is relatively inexpensive, does not require a vacuum device or the like and can cope with a large area.

[0010]

[Problems to be Solved by the Invention]

In order to produce a higher precision image-forming apparatus such as the above image display device, it is necessary to form high precision wirings made of electroconductive films which supply electric current to respective electron-emitting devices for driving.

[0011]

Thus, a method of using photosensitive paste has been proposed for formation of such wirings.

[0012]

Also, in the case of fabricating a large-area image-forming apparatus having a diagonal line of several tens cm, it is necessary that the wirings used in the interior of the image-forming apparatus have a lower resistance. To achieve this, it is important to make the film-thickness of the

wirings thick.

[0013]

However, in the case of using a photosensitive paste for the purpose of forming high precision thick wirings, the following problems arise.

[0014]

In general, a process of fabricating the wirings by using a photosensitive paste is conducted in the order of forming of the photosensitive paste film, (drying), exposing, developing, and burning.

[0015]

However, in the case of fabricating wirings by forming a thick photosensitive paste film at one time and then sequentially implementing (drying), exposing, developing, and baking for the purpose of forming the thick film, the following problems arise.

[0016]

That is, in Fig. 15 where reference numeral 11 denotes a substrate, 12 denotes a photosensitive paste, 13 denotes a mask, 14 denotes a develop pattern as a developing image and 21 demotes a process, (a) represents a film forming process, (b) an exposure process, (c) a developing process, and (d) a baking process. In the case of fabricating wirings in that order, the curling of an edge portion of the baked wiring pattern 21 such as warping (hereinafter, referred to as

"edge curl") increases, and when an insulating layer is laminated on the wiring pattern in a succeeding process, spaces defined by both of the sides of the wiring pattern 21 and existing under the edge curl portions are insufficiently filled with an insulating material. Thereby, spaces remain there.

[0017]

It is presumed that this is caused by a reduction in volume resulting from the evaporation of a solvent or the like in the baking process of (d), or the short of the light-amount at exposure which is due to a large thickness of the photosensitive paste.

[0018]

On the other hand, if the amount of exposure-light is increased to eliminate the above shortage, a co-called over exposure occurs, resulting in cases where the sharpness of the edge portion of the wiring pattern 21 becomes low, or the width of a pattern is made larger than a desired width.

[0019]

Also, regarding the wirings made of electroconductive films, when a matrix wiring (row-directional wirings and column-directional wirings) to be used in an image display device shown in Fig. 14 is formed of the electroconductive films, it is necessary that after the lower-layer wiring positioning on the lower side is formed, an insulating layer

is formed, and thereafter, the upper-layer wiring is laminated thereon in order to insulate the row-directional wirings and the column-directional wirings from each other.

[0020]

Thus, in the case of using wirings with the above curled portions as the lower-layer wiring on the lower side, the insulating layer is formed on the lower-layer wiring having curled edges.

[0021]

Thus, when the insulation layer is formed by a printing method, the spaces existing on both of the sides of the lower-layer wiring and on the lower side of the curled edge portion cause bubbles to be produced in the insulation layer during the baking process required for the printing method.

[0022]

As a result, the bubbles in the insulation layer deteriorates the insulating property between the row-directional wirings and the column-directional wirings. In the worst case, there may occur such a problem that the row-directional wirings and the column-directional wirings are short-circuited.

[0023]

Also, in the above-mentioned image-forming apparatus, a high voltage of several kV to several tens kV is applied to a metal back arranged on the face place. For this reason,

if a wiring (electroconductive film) having the above-mentioned curled edges exists on a facing rear plate, the possibility with which a discharge phenomenon starting from the curled edge portions occurs becomes high.

[0024]

The curled edges in question are remarkably observed when the film thickness of the baked photosensitive paste exceeds 5 μm, and the amount of curled edge becomes larger as the film thickness becomes thick.

[0025]

For example, in the case where the thickness of a portion A after the baking in Fig. 15(e) is 10 μm, the curled edge which is represented by the film thickness of a portion B in Fig. 15(e) becomes 18 to 21 μm.

[0026]

The film thickness of the portion A is the height from the substrate surface of the portion of the wiring pattern 21 end part excluding the curled edge portions. The film thickness of the portion B is the height of the curled edge portion of the wiring pattern 21 end part.

[0027]

Accordingly, the curled amount of edge (B/A) is about twice. In the present specification, the curled amount of edge is defined as a ratio of B to A in Fig. 15, and in this case, that the curled amount of edge is about twice means

B/A = (18/10) to (21/10) ≅ 2.

[0028]

If the curled amount of edge is thus about twice, the formation of the insulation layer to be laminated in a following process is adversely affected due to the height of the curled edge portion, when the above-mentioned matrix wirings are formed.

[0029]

In some cases, the curled amount of edge is comparable to the thickness of substantially one layer of the insulation layer, depending on the thickness of the insulation layer. In this case, with respect to the thickness, the substantially one insulating layer is canceled by the edge curled portion.

[0030]

For that reason, if a desired insulation performance is to be obtained, it becomes necessary to form an excessively thicker insulating layer, taking the curled amount of edge into consideration. Moreover, as a result of forming the thicker insulation layer, in some cases, an unnecessary step is formed when the upper layer-layer wiring is formed on the upper side after the insulation layer is formed. This results in the disconnection of the upper-layer wiring at the upper side.

[0031]

Also, if the terminals (lead-out) of wirings in the image-forming apparatus have curled edge portions, the curled edge portions may be broken or a contact failure may occur when flexible mounting is carried out.

[0032]

The present invention has been made in order to solve the above-mentioned problems of the conventional art, and therefore, an object of the present invention is to provide methods of manufacturing an electroconductive film, a circuit substrate, an electron source and an image-forming apparatus, and the electroconductive film, the circuit substrate, the electron source and the image-forming apparatus, which reduce the curling of edges.

[0033]

[Means for Solving the Problems]

To achieve the above object, the method of producing an electroconductive film of the present invention comprises: a film-forming step of forming a film containing a photosensitive material and an electroconductive material on a substrate; an exposure step of irradiating a light on a desired region on the film formed in the film-forming step, at least two times to form a latent image on the film; a developing step of removing the non-latent image region of the film after the exposure step to form a developed image; and a baking step of baking the developed image formed in

the developing step.

[0034]

Preferably, in the exposure step, a light is irradiated at the second time and the succeeding time to form a latent image having a different size from that of the latent image formed by irradiation at the first time.

[0035]

The method of the present invention comprises: a laminate-film forming step of repeating a film-forming step of forming a film containing a photosensitive material and an electroconductive material and an exposure step of irradiating a light on a desired region of the film formed in the film-forming step, sequentially at least two times, whereby the formed films are laminated, and thus, the latent images of the respective layers are integrated to form a laminate latent image; a developing step of removing the non-latent image regions of the laminate film at one time after the laminate film is formed, to form a developed image; and a baking step of baking the developed image formed in the developing step.

[0036]

Preferably, in the laminate-film forming step, each latent image of the second layer and a succeeding layer is formed so as to have a size different from that of the latent image of the first layer on the substrate.

[0037]

Preferably, in the exposure step, the opening portion of the mask having an opening portion for irradiating a light onto a desired region of the film is changed, whereby the latent images having different sizes are formed.

[0038]

Preferably, in the exposure step, the interval between the mask having an opening portion for irradiating a light onto a desired region of the film and the film is changed at irradiation of a light, whereby the latent images having different sizes are formed.

[0039]

Preferably, the electroconductive material is a metal.

[0040]

Preferably, the electroconductive material comprises electroconductive grains.

[0041]

Preferably, the film-thickness after the baking step is not less than 5 μm.

[0042]

In the method of producing a circuit substrate having a wiring of the present invention, characteristically, the wiring is formed by the above-described method of producing an electroconductive film.

[0043]

in the method of producing an electron source of the present invention, the electron source having a wiring and an electron-emitting device capable of being driven when an electric current is supplied to the wiring, characteristically, the wiring is formed by the above-described method of producing an electroconductive film.

[0044]

In the method of producing an image forming apparatus of the present invention, the apparatus having an electron source and an image forming member capable of forming an image by means of an electron emitted from the electron source, characteristically, the electron source is formed by the above-described method of producing an electron source.

[0045]

In the electroconductive film of the present invention, characteristically, the film is produced by the above-described method of producing an electroconductive film.

[0046]

The circuit substrate of the present invention includes a wiring using the above-described electroconductive film.

[0047]

The electron source of the present invention comprises a wiring using the above-described electroconductive film, and an electron-emitting device capable of being driven when an electric current is supplied to the wiring.

[0048]

The image forming apparatus of the present invention comprises the above-described electron source, and an image forming member capable of forming an image by means of an electron emitted from the electron source.

[0049]

The method of producing an electroconductive film of the present invention comprises: (A) a film-forming step of forming a film containing a photosensitive material and an electroconductive material on a substrate; (B) an exposure step of irradiating a light on a desired region of the film formed in the film-forming step and containing the photosensitive and the electroconductive material, at least two times; (C) a developing step of removing the non-exposed region or the exposed region of the film having an exposed region exposed in the exposure step and a non-exposed region; (D) a baking step of baking the film after it is subjected to the developing step.

[0050]

The method of producing an electroconductive film comprises:

a laminate-film forming step of repeating (A) a film-forming step of forming a film containing a photosensitive material and an electroconductive material on a substrate, and (B) an exposure step of irradiating a light on a desired region of

the film formed in the film-forming step, sequentially at least two times, whereby the plural films each containing an exposed region and a non-exposed region are laminated to form a laminate film; (C) a developing step of removing the non-exposed region or the exposed region in the laminate film; and (D) a baking step of baking the laminate film after the film is subjected to the developing step.

[0051]

Preferably, in the film-forming step, a paste containing the photosensitive material and the electroconductive material is coated onto the substrate.

[0052]

Preferably, the electroconductive material is a metal.

[0053]

Preferably, the electroconductive material comprises electroconductive grains.

[0054]

In the electroconductive film of the present invention, characteristically, the film is produced by the above-described method of producing an electroconductive film.

[0055]

Preferably, the film-thickness is not less than 5 μm.

[0056]

The circuit substrate of the present invention, the substrate having a wiring, characteristically, the above-

described electroconductive film is used as a wiring.

[0057]

In the electron source of the present invention, the source having an electron-emitting device formed on a substrate and a wiring for driving the electron-emitting device, characteristically, the above-described electroconductive film is used as a wiring.

[0058]

The image forming apparatus of the present invention comprises the above-described electron source, and an image forming member.

[0059]

In the method of producing a circuit substrate of the present invention, the substrate having a wiring formed of an electroconductive film, characteristically, the electroconductive film is formed by the above-described method of producing an electroconductive film.

[0060]

In the method of producing an electron source of the present invention, the electron source having an electron-emitting device formed on a substrate and a wiring formed of an electroconductive film for driving the electron-emitting device, characteristically, the electroconductive film is formed by the above-described method of producing an electroconductive film.

[0061]

In the method of producing an image forming apparatus of the present invention, the source having an electron source and an image forming member, characteristically, the electron source is formed by the above-described method of producing an electron source.

[0062]

Thus, the electroconductive film formed by the method of the present invention has a reduced edge curl.

[0063]

In the circuit substrate and the electron source using the electroconductive film with a reduced edge curl, the cause of bubbles contained in the insulation layer when an insulation layer is formed on the wiring by printing is eliminated. As a result, circuit substrates and electron sources having an enhanced insulating property and satisfactory performances, which are useful in various fields, can be formed.

[0064]

Similarly, a wiring lead-out portion can be structured so as to have a reduced edge curl. Breaking and contact failures can be prevented. This facilitates the mounting of a flexible board on the lead-out portion.

[0065]

[Description of the Embodiments]

Hereinafter, a description will be given in more detail of preferred embodiments of the present invention with reference to the accompanying drawings by way of an example. The scope of the present invention is not omitted to the dimensions, the materials, the shapes and the relative arrangement of the structural parts, etc., described in the embodiments so far as no specific description is made.

[0066]

Of the terms used in the following description, the terms employed in reference to the related arts have the same meanings as those described in Related Art. Also, the "photosensitive paste" in the present invention is directed to a paste material containing at least an electroconductive material composed of a simple substance or compound of metal such as silver, copper or the like which functions as a wiring (electroconductive film) material, a photosensitive material having a photosensitive characteristic, and a solvent. Also, glass grains, a sensitizer or the like is appropriately added to the above-mentioned "photosensitive paste", in addition to the above materials.

[0067]

(First Embodiment)

Fig. 1 is a schematic view showing a process of manufacturing a wiring (electroconductive film) in accordance with this embodiment. Fig. 1(a) is a diagram

showing a state in which a photosensitive paste film has been formed; Fig. 1(b) is a diagram showing a state in which exposure is made; Fig. 1(c) is a diagram showing a state in which second exposure is made; Fig. 1(d) is a diagram showing a state in which developing has been made; and Fig. 1(e) is a diagram showing a state in which baking has been made.

[0068]

Referring to Fig. 1, reference numeral 11 denotes a substrate; 12 denotes a layer which is a film formed by coating a photosensitive paste; 13 denotes a mask used for irradiating a light onto only a desired region of the layer 12; 14 and 17 denote exposure lights; 15 and 18 denote latent images formed by exposure; 19 denotes a developed pattern as a developed image; and 20 denotes a completed wiring pattern (electroconductive film).

[0069]

Hereinafter, a method of forming a wiring (electroconductive film) on the substrate 11 will be described.

[0070]

Figs. 1(a) to 1(e) show a film forming process, an exposure process, a developing process, and a baking process in the state order. In Fig. 1(a), the substrate 11 is made of soda lime glass, and the layer 12 is formed on the

substrate 11 by using a photosensitive paste. That is, the layer 12 which is a film containing the photosensitive material and the electroconductive material therein is formed on the substrate 11.

[0071]

The photosensitive paste mainly contains silver as an electroconductive material. The paste contains about 60 to 80% of silver grains and about 20 to 40% of an organic 94 component having a photosensitivity as a photosensitive material, glass frit, and a solvent component. The photosensitive paste containing the electroconductive material is formed into a film on the substrate 11 by screen printing.

[0072]

Plates having a roughness of around # 150 to # 400 are selectively used, depending on a desired final thickness. In this case, a plate having a roughness of # 200 is used to form a film so that the film thickness after drying of the layer 12 was 12 μm or more.

[0073]

Thereafter, for the purposed of drying the photosensitive paste, drying is implemented at about 80 to 150°C. The thickness after drying of the layer 12 is about 13 μm.

[0074]

Subsequently, in Fig. 1(b), the mask 13 is disposed having a desired opening portion corresponding to a wiring pattern is disposed, and the layer 12 having the photosensitive paste dried is exposed.

[0075]

In this case, the exposure light 14 passes through the opening portion of the mask 13, so that the photosensitive paste layer 12 is exposed as shown in this figure. Reference numeral 15 denotes a latent image which is an exposed portion of the photosensitive paste.

[0076]

Then, in Fig. 1(c), in the same method as that of the first exposure, second exposure is conducted by using a mask 13' having a opening portion smaller that that of the mask 13 used in the fist exposure. In this case, the centers of the second pattern (exposed region) is aligned so as to be superposed on that of the first pattern (exposed region). Reference numeral 18 denotes a latent image which is a portion of the photosensitive paste which has been subjected to the second exposure.

[0077]

After the exposure has been repeated twice as described above, the developing process is implemented on the photosensitive paste layer 12 having a height of about 13 μm in Fig. 1(d).

[0078]

Developing differs depending on a photosensitive paste to be used. The developed pattern 19 in this figure is formed by developing with a weak alkalescent solution, rinsing with refined water to stop the development, and blowing to dry.

[0079]

In addition, as shown in Fig. 1(e), baking is implemented, and thus, a desired wiring pattern 20 is formed. In this case, the baking is implemented at about 500°C. The thickness after baking of the wiring pattern 20 is about 7μm.

[0080]

In this case, the portion having the smallest thickness in the section of the wiring pattern 20 is the center portion which has a thickness of about 7 μm. The portion having the largest thickness is the end portion which has a thickness of about 8 to 10 μm. Thus, the wiring pattern 20 can be formed with the curled amount of edge of about 1.1 to 1.4 times.

[0081]

As described above, the exposure process is repeated twice, and the developing process and the subsequent processes are carried out, and thereby, the curling of edge formed on the wiring pattern 20 can be remarkably reduced.

[0082]

The edge curl is reduced as described above. In the case where the production method of this embodiment is applied to a matrix wiring, and the insulation layer is formed on the lower-layer wiring, the edge curl is reduced. Thus, when the lamination is carried out, the generation of bubbles in the insulation layer decreases, and the formation of holes or the growth of the bubbles is inhibited.

[0083]

Also, even if an upper-layer wiring is formed on the insulation layer, the insulation layer exhibits an excellent insulating property, and defects that lead to short-circuiting are remarkably reduced.

[0084]

Also, the insulation layer having a sufficient insulating property can be formed while it is not necessary to increase the number of insulation layers to be laminated on each other in a following process, since the curling of edge is reduced.

[0085]

Also, when the upper-layer wiring is formed on the insulation layer, the disconnection of the upper-layer wiring at a step, which is due to the edge curl, is eliminated.

[0086]

Also, the buildup of the curled edge portion is small

in the end portion (terminal portion). Thus, when flexible mounting is conducted, damages such as the breaking of a wiring and so forth do not occur, and contact failures do not also occur.

[0087]

Also, when the flexible board is replaced by a new one, problems such as cracks of the line of the wiring do not occur.

[0088]

(Second Embodiment)

Fig. 2 is a schematic view showing a process of manufacturing a wiring (electroconductive film) in accordance with this embodiment. Fig. 2(a) is a diagram showing a state in which a photosensitive paste film has been formed; Fig. 2(b) is a diagram showing a state in which exposure is made; Fig. 2(c) is a diagram showing a state in which a second layer has been formed; Fig. 2(d) is a diagram showing a state in which second exposure is made; Fig. 2(e) is a diagram showing a state in which developing has been made; and Fig. 2(f) is a diagram showing a state in which baking has been made.

[0089]

Referring to Fig. 2, reference numeral 11 denotes a substrate; 12 and 16 denote first and second layers formed by coating a photosensitive paste; 13 denotes a mask; 14 and

17 denote exposure lights; 15 and 18 denote latent images; 19 denotes a developed pattern; and 20 denotes a wiring pattern.

[0090]

Hereinafter, a method of forming a wiring on the substrate will be described.

[0091]

Figs. 2(a) to 2(f) show a film forming process, an exposure process, a film forming process, an exposure process, a developing process, and a baking process in the state order.

[0092]

In Fig. 2(a), the substrate 11 is made of soda lime glass, and the layer 12 (hereinafter, referred to as a first layer) is formed on the substrate 11 by using a photosensitive paste.

[0093]

The photosensitive paste mainly contains silver, and includes about 60 to 80% of silver grains and about 20 to 40% of a glass component, an organic component having a photosensitivity, and a solvent component. The photosensitive paste having an electroconductivity is formed into a film on the substrate 11 by screen printing.

[0094]

Plates having a roughness of around # 150 to # 400 are

selectively used, depending on a desired final thickness. In this case, a plate having a roughness of # 325 is used to form a film so that the film thickness after drying of the first layer 12 is 10 μm or more.

[0095]

Thereafter, for the purposed of drying the photosensitive paste, drying is implemented at about 80 to 150° C. The thickness after drying of the first layer 12 is about 11 μm.

[0096]

Subsequently, in Fig. 2(b), the mask 13 having a desired opening portion corresponding to a wiring pattern is disposed in such a manner that a desired region of the first layer 12 of the dried photosensitive paste can be exposed, and thereafter, the paste is exposed.

[0097]

In this case, as shown in this figure, the exposure light 14 passes through the opening portion of the mask 13, so that the first layer 12 of the photosensitive paste is exposed. Reference numeral 15 denotes a latent image which is an exposed portion of the photosensitive paste of the first layer 12.

[0098]

Then, in Fig. 2(c), a photosensitive paste layer 16 as a second layer (hereinafter, referred to as "second layer")

is formed in the same manner as that of the first layer 12, and thereafter drying is implemented in the same manner as that of the first layer 12. The overall layer (the first layer 12 + the second layer 16) of the photosensitive paste after the drying has a total film-thickness of about 22 μm.

[0099]

Then, in Fig. 2(d), the exposure is implemented using the same mask as that used in the exposure process of the first layer 12. In this case, alignment is made so that the pattern (exposure region) of the first layer 12 and the second exposure region are superposed on each other.

[0100]

In this case, the exposure light 17 passes through the opening portion of the mask 13, so that the second layer 16 of the photosensitive paste is exposed as shown in this figure. Reference numeral 18 denotes a latent image which is an exposed portion of the second layer 16.

[0101]

The exposure is repeated twice as described above. The above-described process is a process of forming a laminate film. Thus, the latent images 15 and 18 are laminated on each other.

[0102]

In Fig. 2(e), after the laminate film having a two-layer structure is formed, the total layer (the first layer

12 + the second layer 16) of the photosensitive paste having a height of about 22 μm id developed together.

[0103]

Developing differs depending on a photosensitive paste to be used. The developed pattern 19 in this figure is formed by developing with a weak alkalescent solution, rinsing with refined water to stop the development, and blowing to dry.

[0104]

In addition, as shown in Fig. 2(f), baking is implemented, and thus, a desired wiring pattern 20 is formed. In this case, the baking is implemented at about 500° C. The thickness after baking of the wiring pattern 20 is about 14 μm.

[0105]

In this case, the portion having the smallest film-thickness in the section of the wiring pattern 20 is the center portion which has a thickness of about 14 μm. The portion having the largest film-thickness is the end portion which has a thickness of about 17 to 18 μm. Thus, the wiring pattern 20 can be formed with the curled amount of edge of about 1.2 to 1.3 times.

[0106]

As described above, the process of the film formation and the exposure is repeated twice to form a two-layer

structure, and in this state, the developing process and the subsequent processes are carried out, and thereby, the curling of edge can be remarkably reduced.

[0107]

According to this embodiment, the edge curl is reduced as described above. In the case where the wiring of this embodiment is applied to a matrix wiring, a defect of short-circuiting between the lower-layer wiring and the upper-layer wiring does not occur.

[0108]

Also, the insulation layer having a sufficient insulating property can be formed. In this case, it is not necessary to increase the number of insulation layers to be laminated on each other in a following process. As a result, the disconnection of the upper-layer wiring at a step, which is due to the edge curl, is eliminated.

[0109]

(Third Embodiment)

Fig. 3 is a schematic view showing a process of manufacturing a wiring in accordance with this embodiment. Fig. 3(a) is a diagram showing a state in which a photosensitive paste film has been formed; Fig. 3(b) is a diagram showing a state in which exposure is made; Fig. 3(c) is a diagram showing a state in which a second layer has been formed; Fig. 3(d) is a diagram showing a state in which

the exposure of the second layer is made; Fig. 3(e) is a diagram showing a state in which a third layer has been formed; Fig. 3(f) is a diagram showing a state in which the exposure of the third layer is made; Fig. 3(g) is a diagram showing a state in which the exposure is made; and Fig. 3(h) is a diagram showing a state in which baking has been made.

[0110]

Referring to Fig. 3, reference numeral 11 denotes a substrate; 12, 16, and 21 denote first, second, and third layers formed by coating a photosensitive paste; 13 denotes a mask; 14, 17, and 22 denote exposure lights; 15, 18, and 23 denote latent images; 24 denotes a developed pattern; and 25 denotes a wiring pattern.

[0111]

The processes of Fig. 3(a) to Fig. 3(d) are carried out similarly to the processes of the second embodiment illustrated in Figs. 2(a) to 2(d).

[0112]

In Fig. 3(a), the substrate 11 is made of soda lime glass, and the first layer 12 made from a photosensitive paste is formed on the substrate 11.

[0113]

The photosensitive paste mainly contains silver, and includes about 60 to 80% of silver grains and about 20 to 40% of a glass component, an organic component having a

photosensitivity, and a solvent component. The photosensitive paste is formed into a film by screen printing. A plate having a roughness of # 400 is used to form a film so that the film thickness after drying is 7 μm or more.

[0114]

Thereafter, for the purposed of drying the photosensitive paste, drying is implemented at about 80 to 150° C. The thickness after drying of the first layer 12 is about 8 μm.

[0115]

Subsequently, in Fig. 3(b), a desired region of the first layer 12 is exposed using the mask 13 having a desired pattern (opening portion).

[0116]

In this case, as shown in this figure, the exposure light 14 passes through the opening portion of the mask 13, so that the first layer 12 of the photosensitive paste is exposed. Reference numeral 15 denotes a latent image which is an exposed portion of the photosensitive paste of the first layer 12.

[0117]

Then, in Fig. 3(c), a photosensitive paste layer 16 as a second layer is formed in the same manner as that of the first layer 12, and thereafter drying is implemented

similarly to the first layer 12. The overall layer (the first layer 12 + the second layer 16) after the drying has a total film-thickness of about 15 μm, which is larger by about 7 μm than the film-thickness of the first layer 12.

[0118]

Then, in Fig. 3(d), the second layer 16 is exposed using the same mask 13, similarly to the exposure process of the first layer 12.

[0119]

In this case, the exposure is carried out in such a manner that the exposed region of the first layer 12 and that of the exposed region of the second layer 16 are superposed on each other.

[0120]

The exposure light 17 passes through the opening portion of the mask 13, so that the second layer 16 of the photosensitive paste is exposed as shown in this figure. Reference numeral 18 denotes a latent image which is an exposed portion of the second layer.

[0121]

In addition, in Fig. 3(e), a third layer of the photosensitive paste (hereinafter, referred to as "third layer") 21 is film-formed in the same manner as that of the second layer 16. Thereafter, drying is implemented in the same manner as that of the second layer 16. The thickness

after drying of the first layer 12, the second layer 16, and the third layer 21 is about 22 μm, which is larger by about 7 μm than the thickness of the first and second layers.

[0122]

In addition, the third layer 21 is exposed by using the same mask 13 in the same manner as that of the second layer 16 in Fig. 3(f).

[0123]

In this case, the exposure is made in such a manner that an exposed region of the third layer 21 is superposed on an exposed region of the second layer 16.

[0124]

The exposure light 22 passes through the opening portion of the mask 13, so that the third layer 21 of the photosensitive paste is exposed as shown in this figure. Reference numeral 23 denotes a latent image which is an exposed portion of the third layer 21.

[0125]

The process of film-formation and exposure is repeated three times as described above to form a three-layer structure. In this state, the photosensitive paste having a height of about 22 μm is developed together in Fig. 3(g).

[0126]

The developing is carried out in the same manner as that in the second embodiment, and a developed pattern 24

shown in this figure is formed.

[0127]

In addition, as shown in Fig. 3(h), baking is implemented, and thus, a desired wiring pattern (electroconductive film) 25 is formed. In this case, the baking is implemented at about 500° C. The thickness after baking of the wiring pattern 25 is about 14 μm. The line-width is about 75 μm.

[0128]

In this case, the portion having the smallest film-thickness in the section of the wiring pattern 25 is the center portion which has a thickness of about 14 μm. The portion having the largest film-thickness is the end portion which has a thickness of about 15 to 17 μm. Thus, the curled amount of edge is about 1.2 to 1.3 times. Thus, a wiring pattern having substantially no edge curl can be formed.

[0129]

As described above, the process of the film-formation and the exposure is repeated three times to form a three-layer structure, and in this state, the developing process and the subsequent processes are carried out, and thereby, the curling of edge can be remarkably reduced.

[0130]

The edge curl is reduced as described above. In the

case where the insulation layer is formed on the wiring pattern 25, the generation of bubbles is reduced. When the lamination is carried out, the formation of holes or the growth of the bubbles is remarkably reduced.

[0131]

Also, since the edge curl is reduced, it is not necessary to increase the number of insulation layers to be laminated on each other in a following process. Thus, the number of processes does not increase. Moreover, when an upper-layer wiring is formed, the generation of unnecessary steps is eliminated.

[0132]

Also, the buildup of the curled edge portion in the terminal portion is small. Thus, when flexible mounting is conducted, damages such as the breaking of the edge curl portion do not occur, and contact failures do not also occur.

[0133]

Also, when the flexible board is replaced by a new one, problems such as cracks of the line of the wiring pattern 25 do not occur.

[0134]

(Fourth Embodiment)

Fig. 4 is a schematic view showing a process of manufacturing a wiring in accordance with this embodiment. Fig. 4(a) is a diagram showing a state in which a

photosensitive paste film has been formed; Fig. 4(b) is a diagram showing a state in which exposure is made; Fig. 4(c) is a diagram showing a state in which a second layer has been formed; Fig. 4(d) is a diagram showing a state in which the exposure of the second layer is made; Fig. 4(e) is a diagram showing a state in which developing has been made; and Fig. 4(f) is a diagram showing a state in which baking has been made.

[0135]

Referring to Fig. 4, reference numeral 11 denotes a substrate; 12 and 16 denote first and second layers formed by coating a photosensitive paste; 13 and 31 denote masks; 14 and 17 denote exposure lights; 15 and 16 denote latent images; 19 denotes a developed pattern; and 20 denotes a wiring pattern (electroconductive film).

[0136]

According to this embodiment, the masks 13 and 14 in Figs. 4(b) and 4(d) are different from each other. Specifically, the opening widths of the masks 13 and 31 are different from each other. The wiring is formed in the same manner as that of the second embodiment except that the mask 31 has a narrow opening. Finally, the developed pattern 19 of which the upper and lower line widths are different from each other is formed.

[0137]

In addition, as shown in Fig. 4(h), baking is implemented, and thus, a desired wiring pattern (electroconductive film) 20 is formed. In this case, the baking is implemented at about 500°C. The thickness after baking of the wiring pattern 20 is about 14 μm. The line-width is about 75 μm.

[0138]

In this case, the portion having the smallest film-thickness in the section of the wiring pattern 20 is the center portion of the second layer which has a thickness of about 14 μm. The portion having the largest film-thickness is the end portion of the second layer which has a thickness of about 17 μm. Thus, a wiring pattern having a curled amount of edge of about 1.2 times is formed.

[0139]

As described above, the process of the film-formation and the exposure is repeated two times to form a two-layer structure, and in this state, the developing process and the subsequent processes are carried out, and thereby, the curling of edge can be remarkably reduced.

[0140]

The edge curl is reduced as described above. In the case where the insulation layer is formed on the wiring pattern 20, the generation of bubbles is reduced. When the lamination is carried out, the formation of holes or the

growth of the bubbles is remarkably reduced. When an electrode is formed thereon, short-circuiting defects can be considerably reduced.

[0141]

Also, since the edge curl is reduced, it is not necessary to increase the number of insulation layers to be laminated on each other in a following process. Thus, the number of processes does not increase. Moreover, when an upper-layer wiring is formed, the generation of unnecessary steps is eliminated.

[0142]

Also, the buildup of the curled edge portion in the terminal portion is small. Thus, when flexible mounting is conducted, damages such as the breaking of the edge curl portion do not occur, and contact failures do not also occur.

[0143]

Also, when the flexible board is replaced by a new one, problems such as cracks of the line of the wiring pattern 25 do not occur.

[0144]

(Fifth Embodiment)

Fig. 5 is a schematic view showing a process of manufacturing a wiring in accordance with this embodiment. Fig. 5(a) is a diagram showing a state in which a photosensitive paste film has been formed; Fig. 5(b) is a

diagram showing a state in which exposure is made; Fig. 5(c) is a diagram showing a state in which a second layer has been formed; Fig. 5(d) is a diagram showing a state in which the exposure of the second layer is made; Fig. 5(e) is a diagram showing a state in which a third layer has been film-formed; and Fig. 5(f) is a diagram showing a state in which the third layer has been exposed; Fig. 5(g) is a diagram showing a state in which the exposure is made; and Fig. 5(h) is a diagram showing a state in which the baking has been made.

[0145]

Referring to Fig. 5, reference numeral 11 denotes a substrate; 12, 16, ad 21 denote first, second, and third layers formed by coating a photosensitive paste; 13, 31, and 41 denote masks; 14, 17, and 22 denote exposure lights; 15, 18, and 23 denote latent images; 24 denotes a developed pattern; and 25 denotes a wiring pattern.

[0146]

According to this embodiment, the masks 13, 31, and 41 in Figs. 5(b), 5(d), and 5(f) are different from each other. Specifically, the opening widths of the masks 13, 31, and 41 are different from each other. The wiring is formed in the same manner as that of the third embodiment except that the masks are sequentially used in such order that the width decreases. Finally, the developed pattern 24 of which the

upper, middle, and lower line widths are different from each other is formed.

[0147]

In addition, as shown in Fig. 5(h), baking is implemented, and thus, the desired wiring pattern 25 is formed. In this case, the baking is implemented at about 500°C.

[0148]

The thickness after baking of the wiring pattern 25 is about 14 μm. The line-width on the lowest side is about 75 μm. In this case, the portion having the smallest film-thickness in the section of the wiring pattern 25 is the center portion of the second layer which has a thickness of about 14 μm. The portion having the largest film-thickness is the end portion of the second layer which has a thickness of about 16 μm. Thus, a wiring pattern having a curled amount of edge of about 1.2 times is formed.

[0149]

As described above, the process of the film-formation and the exposure is repeated three times to form a three-layer structure, and in this state, the developing process and the subsequent processes are carried out, and thereby, the curling of edge can be remarkably reduced.

[0150]

The edge curl is reduced as described above. In the

case where the insulation layer is formed on the wiring pattern 25, the generation of bubbles is reduced. When the lamination is carried out, the formation of holes or the growth of the bubbles is remarkably reduced. When an electrode is formed thereon, short-circuiting defects can be considerably reduced.

[0151]

Also, since the edge curl is reduced, it is not necessary to increase the number of insulation layers to be laminated on each other in a following process. Thus, the number of processes does not increase. Moreover, when an upper-layer wiring is formed, the generation of unnecessary steps is eliminated.

[0152]

Also, the buildup of the curled edge portion in the terminal portion is small. Thus, when flexible mounting is conducted, damages such as the breaking of the edge curl portion do not occur, and contact failures do not also occur.

[0153]

Also, when the flexible board is replaced by a new one, problems such as cracks of the line of the wiring pattern 25 do not occur.

[0154]

(Sixth Embodiment)

Fig. 6 is a schematic view showing a process of

manufacturing a wiring in accordance with this embodiment. Fig. 6(a) is a diagram showing a state in which a photosensitive paste film has been formed; Fig. 6(b) is a diagram showing a state in which exposure is made; Fig. 6(c) is a diagram showing a state in which a second layer has been formed; Fig. 6(d) is a diagram showing a state in which the exposure of the second layer is made; Fig. 6(e) is a diagram showing a state in which the exposure is made; and Fig. 6(f) is a diagram showing a state in which the baking has been made.

[0155]

Referring to Fig. 6, reference numeral 11 denotes a rear plate; 12 and 16 denote first and second layers formed by coating a photosensitive paste; 13 and 31 denote masks; 14 and 17 denote exposure lights; 15 and 18 denote latent images; 19 denotes a developed pattern; and 20 denotes a wiring pattern.

[0156]

According to this embodiment, the masks 13 and 31 shown in Fig. 6(b) and 6(d) are different from each other. Specifically, the opening widths of the masks 13 and 31 are different from each other. The wiring is formed in the same manner as that of the third embodiment except that the mask 31 has a larger opening width. Finally, the developed pattern 19 of which the upper and lower line widths are

different from each other is formed as shown in Fig. 6(e).

[0157]

In addition, as shown in Fig. 6(f), baking is implemented, and thus, the desired wiring pattern 20 is formed. In this case, the baking is implemented at about 500°C. The thickness after the baking of the wiring pattern 20 is about 14 μm.

[0158]

In this case, the portion having the smallest film-thickness in the section of the wiring pattern 20 is the center portion thereof having about 14 μm. The portion having the largest film-thickness has a thickness of about 16 μm. Thus, the wiring pattern 20 having substantially no edge curl is formed.

[0159]

The edge curl is reduced as described above. In the case where the insulation layer is formed on the wiring pattern 20, the generation of bubbles is reduced. When the lamination is carried out, the formation of holes or the growth of the bubbles is remarkably reduced. When an electrode is formed thereon, short-circuiting defects can be considerably reduced.

[0160]

Also, since the edge curl is reduced, it is not necessary to increase the number of insulation layers to be

laminated on each other in a following process. Thus, the number of processes does not increase. Moreover, when an upper-layer wiring is formed, the generation of unnecessary steps is eliminated.

[0161]

Also, the buildup of the curled edge portion in the terminal portion is small. Thus, when flexible mounting is conducted, damages such as the breaking of the edge curl portion do not occur, and contact failures do not also occur.

[0162]

Also, when the flexible board is replaced by a new one, problems such as cracks of the line of the wiring pattern 20 do not occur.

[0163]

(Seventh Embodiment)

Fig. 7 is a schematic view showing a process of manufacturing a wiring in accordance with this embodiment. Fig. 7(a) is a diagram showing a state in which a photosensitive paste film has been formed; Fig. 7(b) is a diagram showing a state in which exposure is made; Fig. 7(c) is a diagram showing a state in which a second layer has been formed; Fig. 7(d) is a diagram showing a state in which the exposure of the second layer is made; Fig. 7(e) is a diagram showing a state in which a third layer has been film-formed; and Fig. 7(f) is a diagram showing a state in

which the third layer has been exposed; Fig. 7(g) is a diagram showing a state in which the exposure is made; and Fig. 7(h) is a diagram showing a state in which the baking has been made.

[0164]

Referring to Fig. 7, reference numeral 11 denotes a substrate; 12, 16, ad 21 denote first, second, and third layers formed by coating a photosensitive paste; 13, 31, and 41 denote masks; 14, 17, and 22 denote exposure lights; 15, 18, and 23 denote latent images; 24 denotes a developed pattern; and 25 denotes a wiring pattern.

[0165]

According to this embodiment, the masks 13, 31, and 41 shown in Figs. 7(b), 7(d), and 7(f) are different from each other. Specifically, the opening widths of the masks 13, 31, and 41 are different from each other. The wiring is formed in the same manner as that of the forth embodiment except that the masks are sequentially used in such order that the opening width increase. Finally, the developed pattern 24 of which the upper, middle, and lower line widths are different from each other is formed as shown in Fig. 7(g).

[0166]

In addition, as shown in Fig. 7(h), the baking is implemented, and thus, the desired wiring pattern 25 is formed. In this case, the baking is implemented at about

500°C. The thickness after the baking of the wiring pattern 25 is about 16 μm.

[0167]

In this case, the portion having the smallest film-thickness in the section of the wiring pattern 25 is the center portion thereof having a thickness of about 14 μm. The portion having the largest film-thickness is the end portion having a thickness of about 19 μm. Thus, the wiring pattern 25 having substantially no edge curl is formed.

[0168]

The edge curl is reduced as described above. In the case where the insulation layer is formed on the wiring pattern 25, the generation of bubbles is reduced. When the lamination is carried out, the formation of holes or the growth of the bubbles is remarkably reduced. When an electrode is formed thereon, short-circuiting defects can be considerably reduced.

[0169]

Also, since the edge curl is reduced, it is not necessary to increase the number of insulation layers to be laminated on each other in a following process. Thus, the number of processes does not increase. Moreover, when an upper-layer wiring is formed, the formation of unnecessary steps is eliminated.

[0170]

Also, the buildup of the curled edge portion in the terminal portion is small. Thus, when flexible mounting is conducted, damages such as the breaking of the edge curl portion do not occur, and contact failures do not also occur.

[0171]

Also, when the flexible board is replaced by a new one, problems such as cracks of the line of the wiring pattern 25 do not occur.

[0172]

(Eighth Embodiment)

Fig. 8 is a schematic view showing a process of manufacturing a wiring in accordance with this embodiment. Fig. 8(a) is a diagram showing a state in which a photosensitive paste film has been formed; Fig. 8(b) is a diagram showing a state in which the exposure is made; Fig. 8(c) is a diagram showing a state in which a second layer has been film-formed; Fig. 8(d) is a diagram showing a state in which the exposure of the second layer is made; Fig. 8(e) is a diagram showing a state in which the developing has been made; and Fig. 8(f) is a diagram showing a state in which the baking has been made.

[0173]

In this embodiment, the same mask is used in the exposure processes shown in Fig. 8(b) and Fig. 8(d). The intervals between the mask 13 during the exposure processes

and the surface of the photosensitive paste film are different from each other. The interval shown in Fig. 8(b) is longer than that in Fig. 8(d), i.e., is set at about 500 μm. The interval in Fig. 8(d) is set at 100 μm. In other respects, the wiring is formed in the same manner as that of the second embodiment.

[0174]

In this way, the developed pattern 19 in which the line-width after the exposure of the upper pattern is shorter than that of the lower pattern can be formed as shown in Fig. 8(e).

[0175]

In addition, the baking is implemented, and thus, the wiring pattern 20 is formed as shown in Fig. 8(f). In this case, the baking is implemented at about 500° C. The thickness after the baking of the wiring pattern 20 is about 14 μm. The line width of the lower pattern is about 75 μm, and that of the upper pattern is about 65 μm.

[0176]

In this case, the portion having the smallest film-thickness in the section of the wiring pattern 20 is the center portion thereof having a thickness of about 14 μm. The portion having the largest film-thickness is the end portion having a thickness of about 17 μm. Thus, the wiring pattern 20 having a curl amount of edge of about 1.2 times

is formed.

[0177]

According to this embodiment, the line width of the respective layers of the photosensitive paste can be changed by use of one mask 13. In addition to the inherent advantage in which the edge curl is inhibited, profitably, it is not necessary to prepare plural masks.

[0178]

The edge curl is reduced as described above. In the case where the insulation layer is formed on the wiring pattern 20, the generation of bubbles is reduced. When the lamination is carried out, the formation of holes or the growth of the bubbles is remarkably reduced. When an electrode is formed thereon, short-circuiting defects can be considerably reduced.

[0179]

Also, since the edge curl is reduced, it is not necessary to increase the number of insulation layers to be laminated on each other in a following process. Thus, the number of processes does not increase. Moreover, when an upper-layer wiring is formed, the formation of unnecessary steps is eliminated.

[0180]

Also, the buildup of the curled edge portion in the terminal portion is small. Thus, when flexible mounting is

conducted, damages such as the breaking of the edge curl portion do not occur, and contact failures do not also occur.

[0181]

Also, when the flexible board is replaced by a new one, problems such as cracks of the line of the wiring pattern 20 do not occur.

[0182]

(Ninth Embodiment)

In this embodiment, an electron source and an image-forming apparatus are formed by using the method of manufacturing a wiring in accordance with the above second embodiment.

[0183]

Hereinafter, a method of manufacturing an electron source and an image-forming apparatus in accordance with the above second embodiment will be described with reference to Figs. 9 to 12.

[0184]

(1) A substrate 11 is prepared, which is a rear plate having SiO_2 with a thickness of 0.5 μm formed on the surface of a blue glass plate by sputtering.

[0185]

(2) On the surface having the SiO_2 formed thereon, electrodes 2 and 3 are formed in such a manner that 1000 pairs each comprising the electrodes 2 and 3 are arranged in

an X-direction, and 5000 pairs are arranged in a Y-direction (Fig. 9(a)).

[0186]

In Fig. 9, for simplification of the description, three pairs are arranged in an X-direction and three pairs are arranged in a Y-direction. Thus, a total of 9 electron-emitting devices are shown.

[0187]

In this embodiment, Pt is used as a material for the electrodes 2 and 3. The electrodes 2 and 3 are formed by photolithography. The interval between the electrodes 2 and 3 is set at 20 μm.

[0188]

(3) A photosensitive paste is coated on the entire surface of the substrate 11, that is, the rear plate, having the electrodes 2 and 3 formed thereon. The paste is coated on the substrate 11 in the same manner as that in the second embodiment to form a first layer 12 made of the photosensitive paste (see Fig. 2(a)).

[0189]

The photosensitive paste used in this embodiment is similar to that in the second embodiment. Ag gains as an electroconductive material, and an acrylic resin as a photosensitive organic material capable of reacting and curing by ultraviolet rays, to which a glass filler or the

like is added, are used.

[0190]

(4) Thereafter, the first layer 12 made of the photosensitive paste is dried, and an exposure light 14 of ultraviolet rays is irradiated (exposure) to the dried first layer 12 using the light-shielding mask 13 having a plurality of stripe-patterned openings (see Fig. 2(b)).

[0191]

(5) Thereafter, the same photosensitive paste as that used in the above process (3) is coated onto the first layer 12 having an exposed region 15 and a non-exposed region. Thus, a second layer 16 made of the photosensitive paste is formed (see Fig. 2(c)).

[0192]

(6) Thereafter, the second layer 16 made of the photosensitive paste is dried, and an exposure light 17 of ultraviolet rays is irradiated (exposure) to the dried second layer 16 using the light-shielding mask 13 having a plurality of stripe-patterned openings used in the above process (4) (see Fig. 2(d)).

[0193]

In this process (6), the exposure is carried out in such a manner that an exposed region 18 of the second layer 16 is substantially superposed on the region 15 exposed in the above process (4).

[0194]

(7) Subsequently, the substrate 11, i.e., the rear plate, is washed with an organic solvent, so that the non-exposed portions of the first layer 12 and the second layer 16 are removed together (development). Thus, the developed pattern 19 is formed (see Fig. 2(e)).

[0195]

(8) Moreover, the substrate 11, i.e., the rear plate, is baked. Thereby, 5000 column-directional wirings 6 having a width of 50 μm are formed at a pitch of 180 μm as the wiring pattern 20 shown in Fig. 2(f) (see Fig. 9(b)). In this process (8), a part of the respective electrodes 3 are covered with the column-directional wirings 6. Thus, the electrodes 3 and the column-directional wirings 6 are connected to each other.

[0196]

(9) Then, an insulating paste containing a glass binder and resin is coated by printing on the respective cross portions of the row-directional wirings 4 to be formed in the succeeding process and the column-directional wirings 6 previously formed, followed by baking. Thus, an insulating layer 5 is formed (Fig. 10(a)).

[0197]

(10) A paste containing Ag grains, a glass binder, and resin is coated in a line pattern by screen printing, and

then baked. Thus, 1000 row-directional wirings 4 are formed (Fig. 10(b)). In this process (10), a part of the respective electrodes 2 are covered with the row-directional wirings 4, so that the electrodes 2 and the row-directional wirings 4 are connected to each other.

[0198]

The row-directional wirings 4 are formed at a width of 150 μm and a interval pitch of 500 μm.

[0199]

(11) Thereafter, an aqueous solution containing Pd is applied to all of the gaps between the electrodes 2 and the electrodes 3, and is baked at 350° C in the atmosphere. Thus, an electron-emitting electroconductive film 7 made of PdO is formed (Fig. 11 (a)).

[0200]

In this embodiment, for the above-mentioned application of ink, an ink jet device having a piezoelectric system, which is an ink jet technique, is used. In this embodiment, as ink containing Pd, aqueous solution containing 0.15% of an organic Pd compound, 0.15% of isopropyl alcohol, 15% of ethylene glycol, and 0.05% of polyvinylalcohol is used.

[0201]

Thus, an electron source substrate (rear plate) to be subjected to the forming is prepared by the above-described process.

[0202]

(12) The electron source substrate to be subjected to the forming is placed in a vacuum chamber. A gas is exhausted from the chamber until the pressure becomes 10^{-4} Pa. Then, hydrogen is introduced, and in this state, "forming process" is carried out. That is, the respective column-directional wirings 6 are set at 0 V, and a pulsed voltage is sequentially applied to the respective row-directional wirings 4. In this process, a current is caused to flow through the respective electron-emitting electroconductive films 7 to forma a gas in a part of the respective electron-emitting electroconductive films 7.

[0203]

In the forming process, a constant voltage pulse of 5 V is repeatedly applied.

[0204]

The voltage waveform is a triangular waveform of which the pulse width and the pulse interval are 1 msec and 10 msec, respectively. The energization forming process is completed when the resistance of the electron-emitting electroconductive film 7 is 1 MΩ or more.

[0205]

(13) The device subjected to the forming process is then subjected to a so-called "activation process". A gas is exhausted from the chamber until the pressure becomes 10^{-6}

Pa. Then, benzonitrile is introduced to 1.3×10^{-4} Pa, and an "activation process" is carried out, in which the respective column-directional wirings 4 are set at 0 V, and a pulsed voltage is applied to the row-directional wirings 4 sequentially and repeatedly. In this process, carbon films are formed on the inside of a gap of the respective electron-emitting electroconductive films and on the film in the vicinity of the gap. Thus, an electron-emitting portion 8 is formed (Fig. 11(b)).

[0206]

In the activation process, a rectangular pulsed voltage of which the pulse peak value is 15 V, the pulse width is 1 msec, and the pulse interval is 10 msec.

[0207]

According to the above-described processes, the electron source substrate (rear plate) 11 having a plurality of electron-emitting devices 74 shown in Fig. 12, arranged thereon is produced.

[0208]

The evaluation of the electric characteristic of the electron source substrate reveals that the insulation between the column-directional wirings 6 and the row-directional wirings 4 is satisfactorily ensured.

[0209]

Hereinafter, a method of producing a face plate 86

shown in Fig. 12 will be described.

[0210]

(14) A face plate substrate 83 made of the same material as that of the substrate 11, i.e., the rear plate, is sufficiently washed and dried. Thereafter, a black color member is formed on the substrate 83.

[0211]

Here, the black color member is formed in a lattice-like fashion so as to provide openings in correspondence with portions where the respective color phosphors are arranged. The black member is formed in such a manner that the pitch of the black member in the Y-direction is the same as that of the column-directional wiring 6, and the pitch in the X-direction is the same as that of the row-directional wirings 4.

[0212]

(15) The respective color phosphors of red, blue, and green are formed on the opening portions of the black member by screen printing.

[0213]

(16) In addition, a filming layer is formed on the black member and the phosphors. A polymethylmethacrylate type resin dissolved in an organic solvent as a material of the filming layer is coated by screen printing, and dried.

[0214]

(17) Subsequently, Al is formed on the filming layer by the evaporation method.

[0215]

(18) Thereafter, the face plate 86 is heated so that the resin contained in the phosphor paste and the filming layer are removed. Thus, the face plate 86 is obtained, in which the image forming member 84, which is a phosphor layer consisting the phosphor and the black member, and the metal back 85 are formed on the sub substrate 83.

[0216]

(19) An outer frame 82 provided with a spacer (not shown) having a high resistant film on its surface and a joint member is disposed between the substrate 11, i.e., the rear plate, and the face plate 86, which are formed in the above-described processes.

[0217]

Then, the face plate 86 and the substrate 11, i.e., the rear plate, are satisfactorily positioned, and in this state, the joint member is heated and pressed in vacuum to be softened so that the respective members are joined to each other. As a result of this sealing process, an envelop (display panel) 88, shown in Fig. 12, having the interior thereof maintained in a high vacuum state is obtained.

[0218]

The high resistant film is disposed on the surface of

the spacer to escape charges stored on the spacer surface by irradiation of electrons onto the spacer surface, to the row-directional wirings 4 or the metal back 5.

[0219]

The space is abutted against the row-directional wirings (wirings to which a scanning signal is applied) 6, since the trajectory of electron beams emitted from a lateral electron-emitting device is prevented from being shielded.

[0220]

Another reason for the abutment lies in that the alignment with the spacer can be easily performed.

[0221]

A driving circuit is connected to lead-out wiring portions led out from the interior of the display panel 88 obtained as described above via a flexible board. Thus, a moving picture is displayed by linear sequential scanning.

[0222]

In this embodiment, a scanning signal is applied to the row-directional wirings 4 of which the sectional area is large. A modulation signal is applied to the column-directional wirings 6.

[0223]

When a moving picture is displayed on the display panel 88 as described above, a very high precision and high-

luminance image is obtained for a long period of time. Also, even if the flexible board is connected to the lead-out portions of the row-directional wirings 6 and the row-directional wirings 4, no cracks of the wirings occur. Also, no pixel defects, which may be caused by a discharge phenomenon, occur.

[0224]

The display panel 88 may have such a structure as to use a substrate 81, which is a rear plate for fixing the substrate 11, in addition to the substrate 11, as in such a known technique shown in Fig. 14.

[0225]

[Advantages]

As described above, according to the present invention, an electroconductive film of which the edge curl is reduced can be formed. Therefore, in the case of the electroconductive film as a wiring, the cause to contain bubbles when an insulation layer is laminated onto the wiring in a following process can be eliminated. Thus, the interlayer insulating property can be prevented from being deteriorated. Thus, the insulation property is enhanced.

[0226]

Since the edge curl is reduced, it is not necessary to excessively increase the number of insulation layers which are provided in a following process. Therefore, when a

upper-layer wiring is formed on the insulation layer, unnecessary steps are not caused.

[0227]

Also, the buildup of the curled edge portion is small in the wiring lead-out portion. Thus, even if flexible mounting is conducted, the breaking of the curled edge portion and contact-failures do not occur. Moreover, problems such as defects in the line of a thick-film wiring do not occur, even if the flexible board is replaced by a new one.

[0228]

For the above reasons, a pixel defect, which may be caused by a discharge phenomenon, can be eliminated from a flat image forming apparatus with a large screen having electron-emitting devices.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a process diagram showing a method of producing a wiring according to a first embodiment.

[Fig. 2]

Fig. 2 is a process diagram showing a method of producing a wiring according to a second embodiment.

[Fig. 3]

Fig. 3 is a process diagram showing a method of producing a wiring according to a third embodiment.

[Fig. 4]

Fig. 4 is a process diagram showing a method of producing a wiring according to a fourth embodiment.

[Fig. 5]

Fig. 5 is a process diagram showing a method of producing a wiring according to a fifth embodiment.

[Fig. 6]

Fig. 6 is a process diagram showing a method of producing a wiring according to a sixth embodiment.

[Fig. 7]

Fig. 7 is a process diagram showing a method of producing a wiring according to a seventh embodiment.

[Fig. 8]

Fig. 8 is a process diagram showing a method of producing a wiring according to an eighth embodiment.

[Fig. 9]

Fig. 9 is a process diagram showing a method of producing an electron source according to a ninth embodiment.

[Fig. 10]

Fig. 10 is a process diagram showing the method of producing an electron source according to the ninth embodiment.

[Fig. 11]

Fig. 11 is a process diagram showing a method of producing an electron source according to the ninth

embodiment.

[Fig. 12]

Fig. 12 is a schematic structural view showing an image forming apparatus according to the ninth embodiment.

[Fig. 13]

Fig. 2 is a schematic view showing an example of a surface conduction electron-emitting device.

[Fig. 14]

Fig. 14 is a schematic structural view showing a known image forming apparatus.

[Fig. 15]

Fig. 15 is a process diagram showing a method of producing a wiring according to a known technique.

[Reference Numerals]

2, 3: electrode

4: row-directional wiring

5: insulation layer

6: row-directional wiring

7: electron-emitting electroconductive film

8: electron-emitting portion

11: substrate

12, 16, 21: layer

13, 13', 31, 41: mask

14, 17, 22: exposure light

15, 18, 23: latent image

19, 24: developed pattern

20, 25: wiring pattern

74: electron-emitting device

81: substrate

82: outer frame

83: face plate substrate

84: image forming member

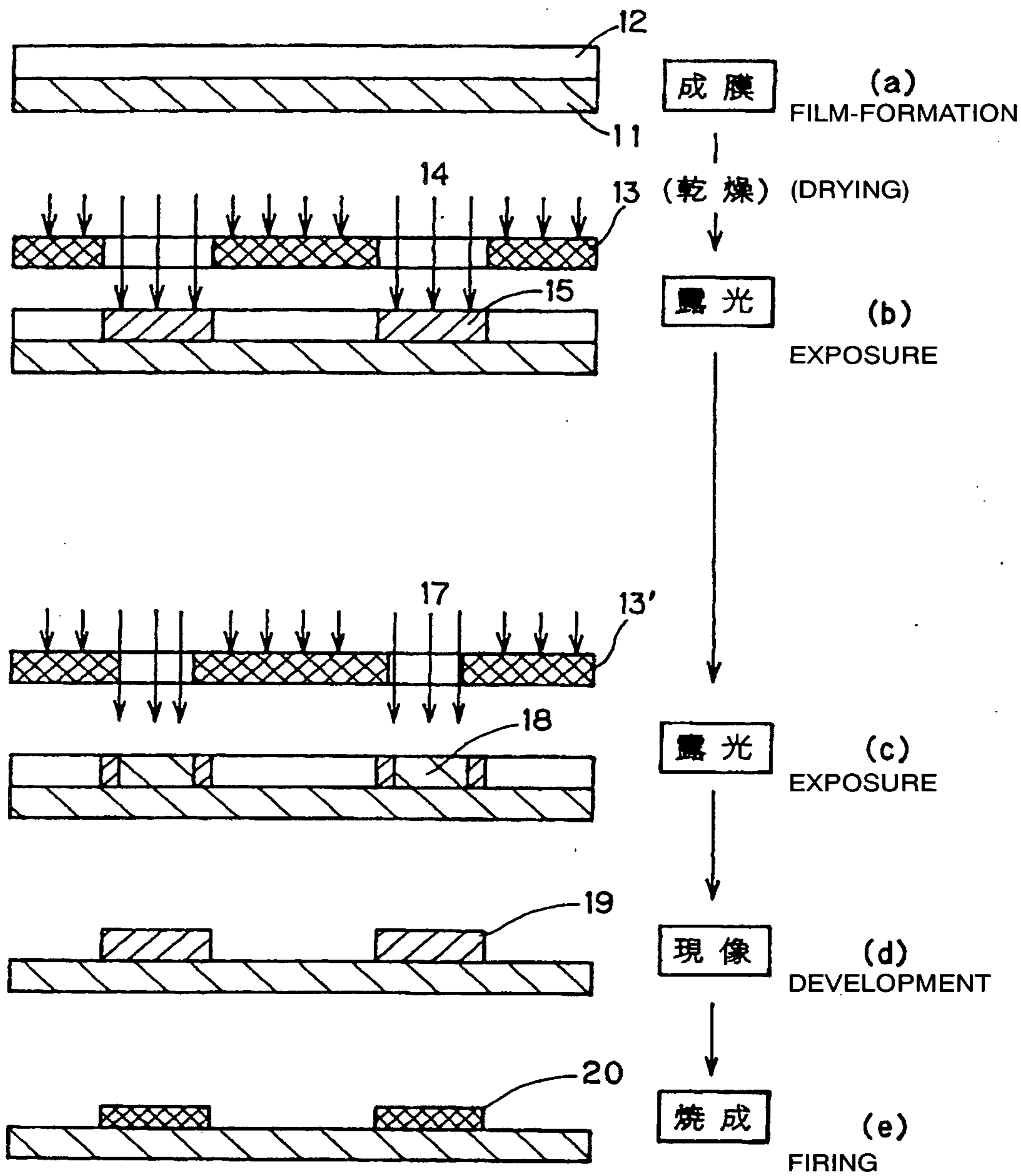
85: metal back

86: face plate

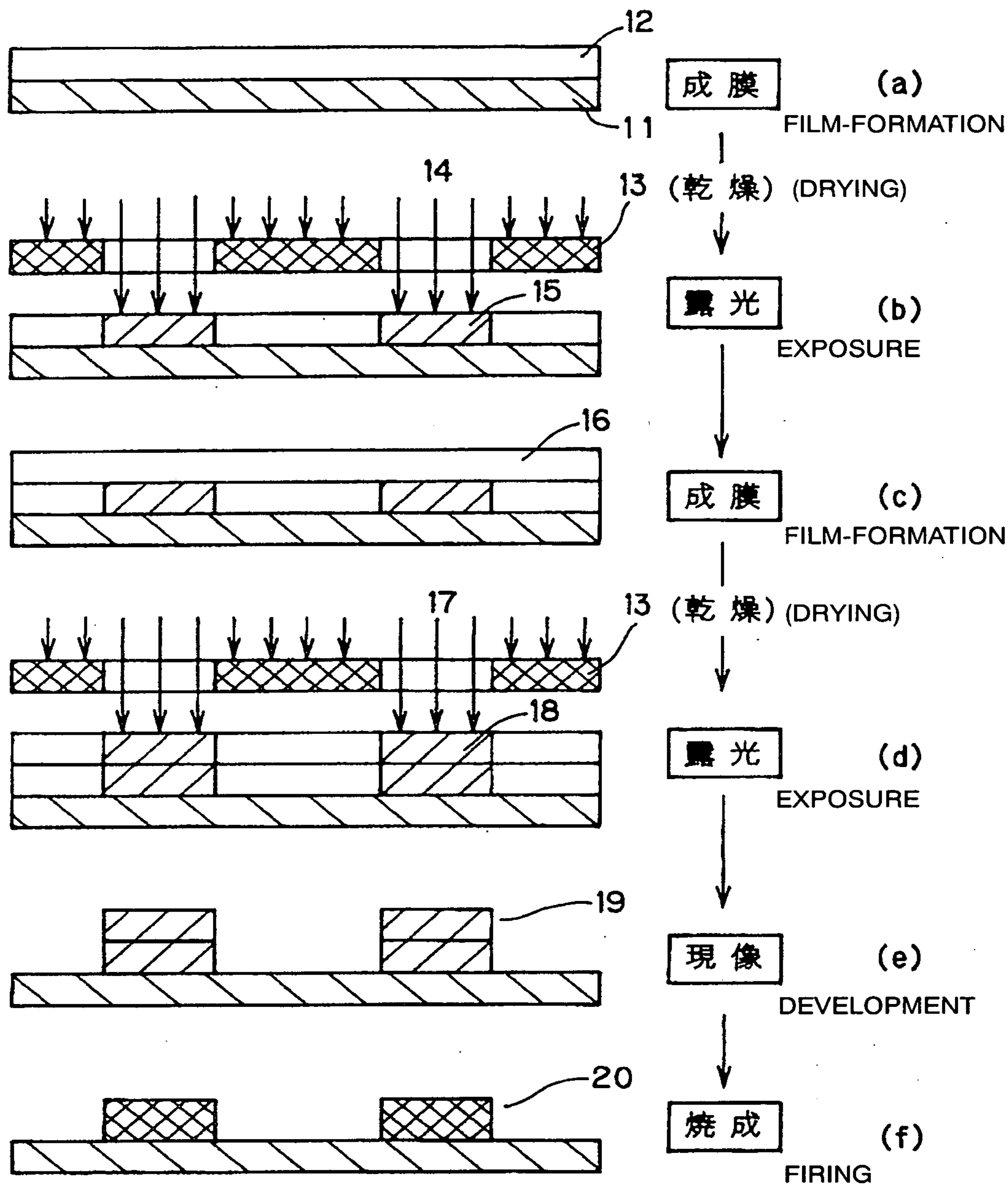
88: display panel

【書類名】　図面　[Name of Document]　DRAWINGS

【図１】　[FIG. 1]



【図２】 [FIG. 2]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成膜
(c)
FILM-FORMATION
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(乾燥) (DRYING)
18
露光
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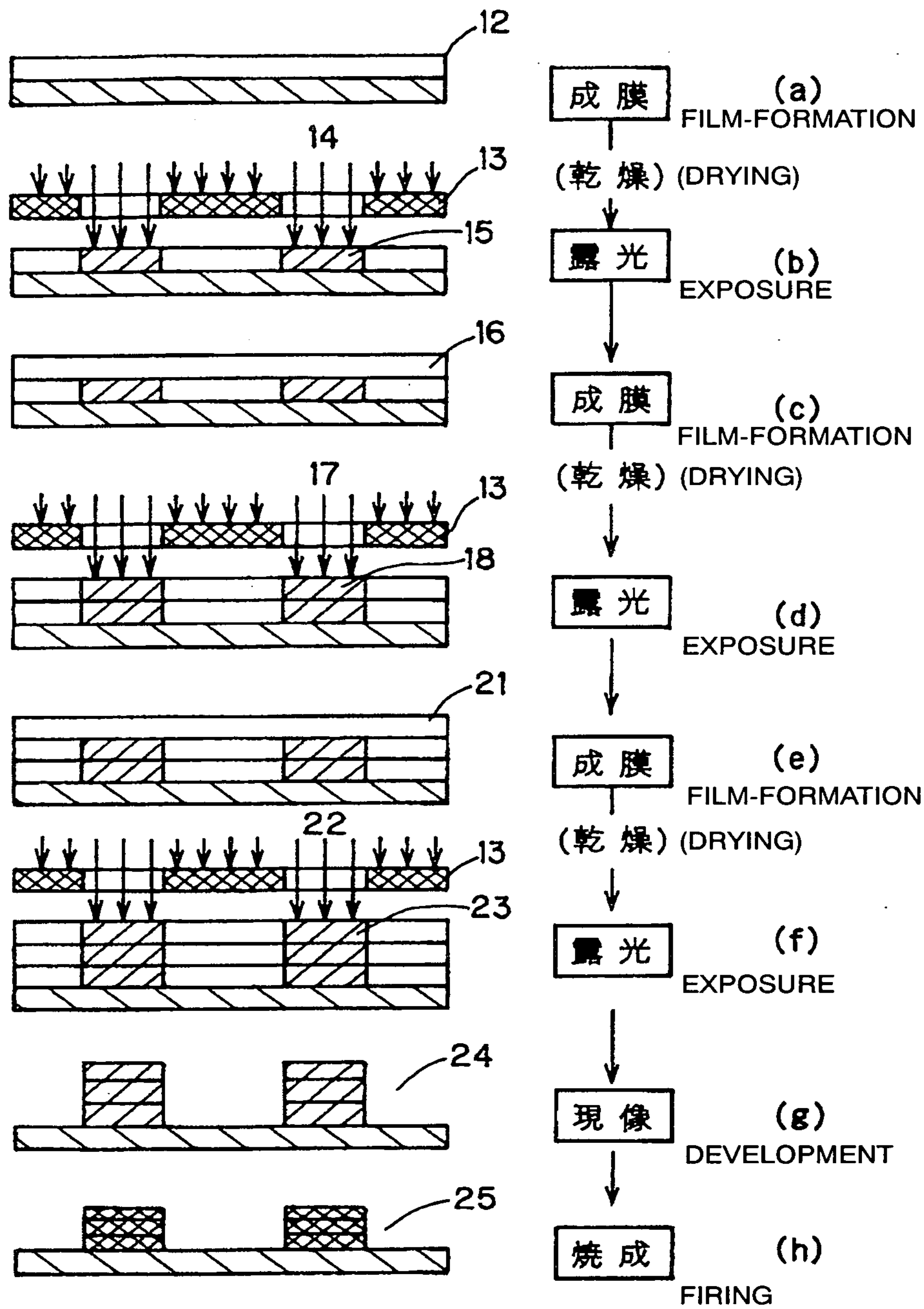
FIRING

【図３】 [FIG. 3]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(d)
EXPOSURE
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(e)
FILM-FORMATION
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EXPOSURE
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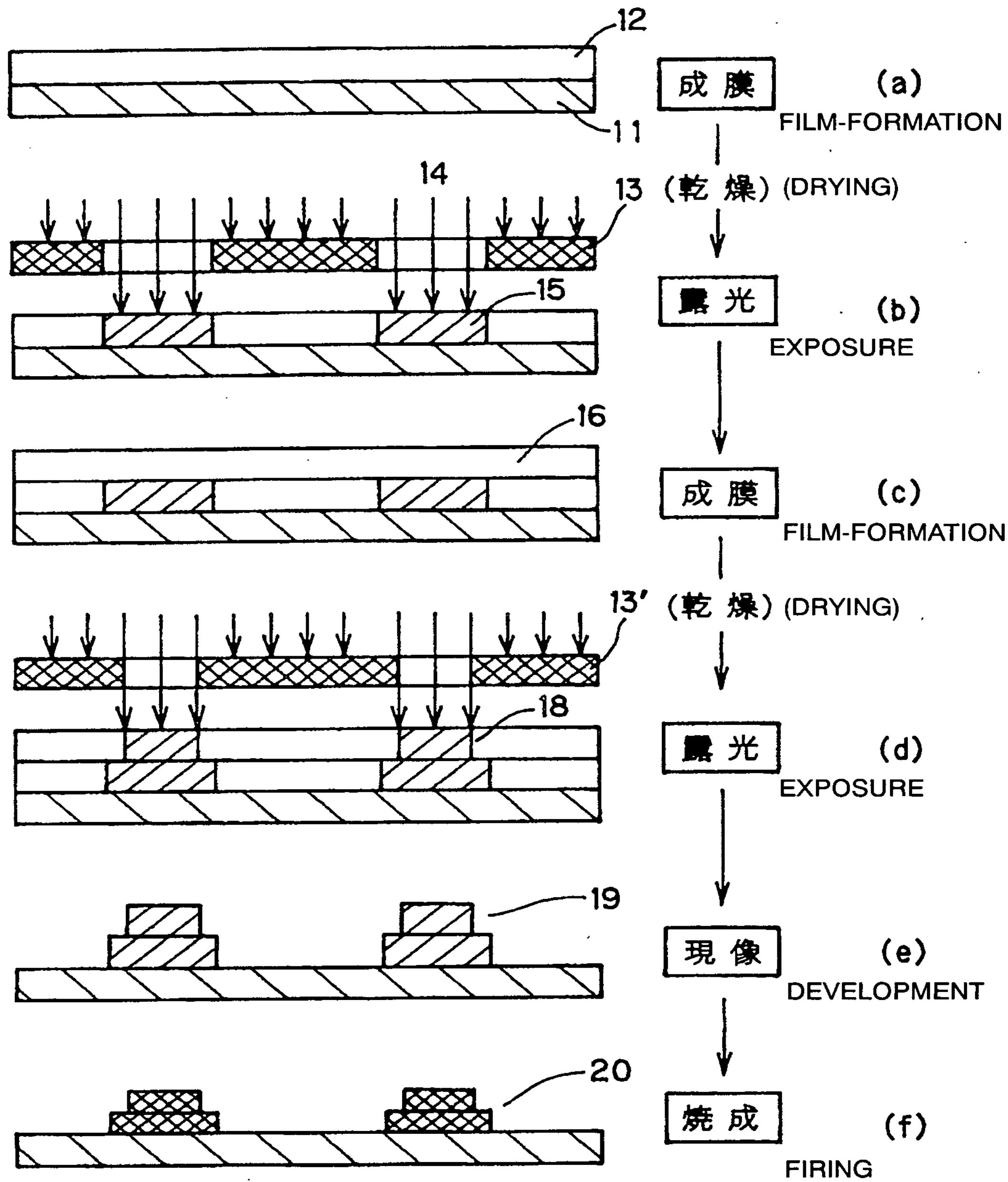
(h)
FIRING

【図４】[FIG. 4]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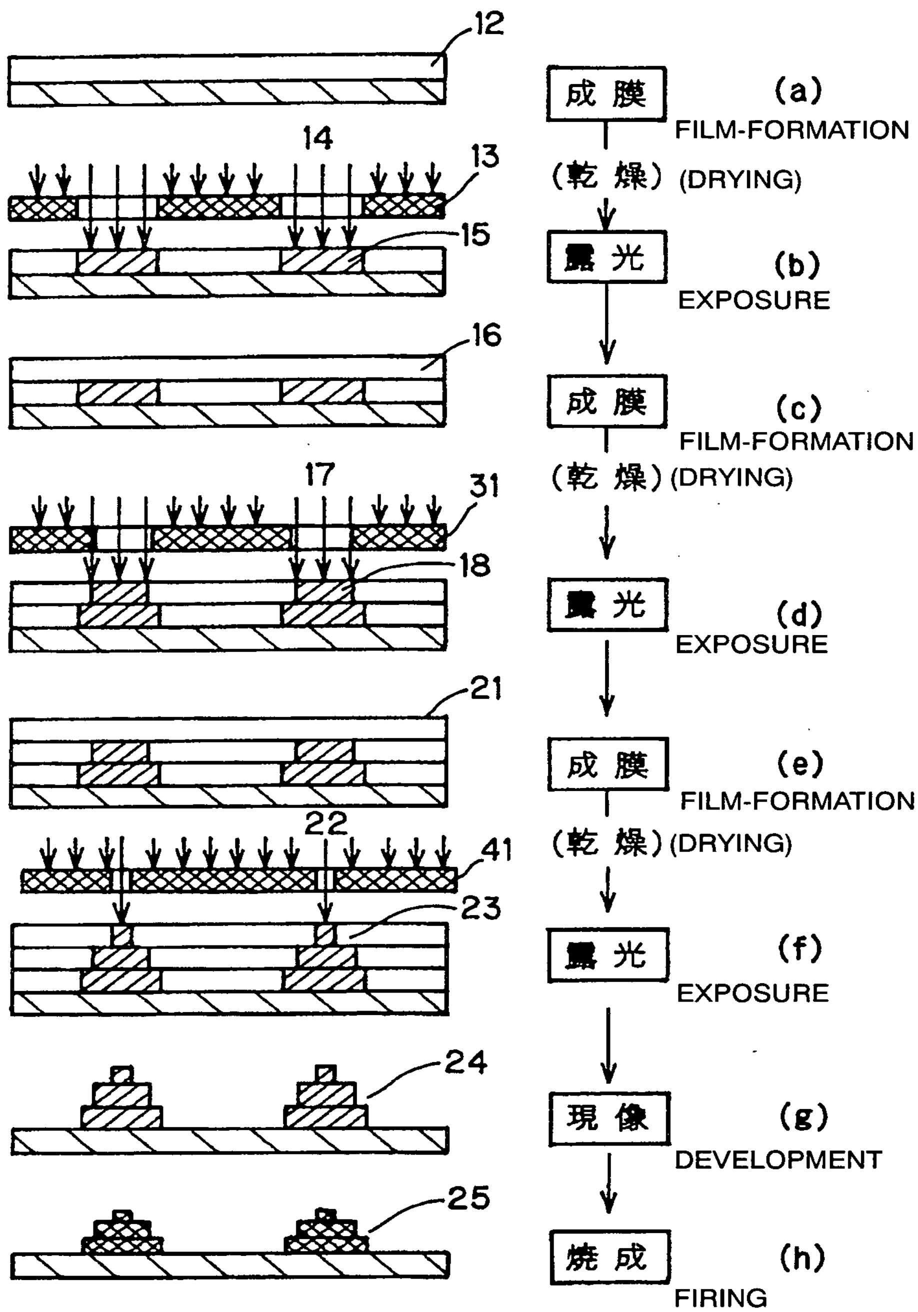
【図５】 [FIG. 5]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(c)
FILM-FORMATION
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31
(乾燥) (DRYING)
18
露光
(d)
EXPOSURE
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成膜
(e)
FILM-FORMATION
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(乾燥) (DRYING)
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露光
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EXPOSURE
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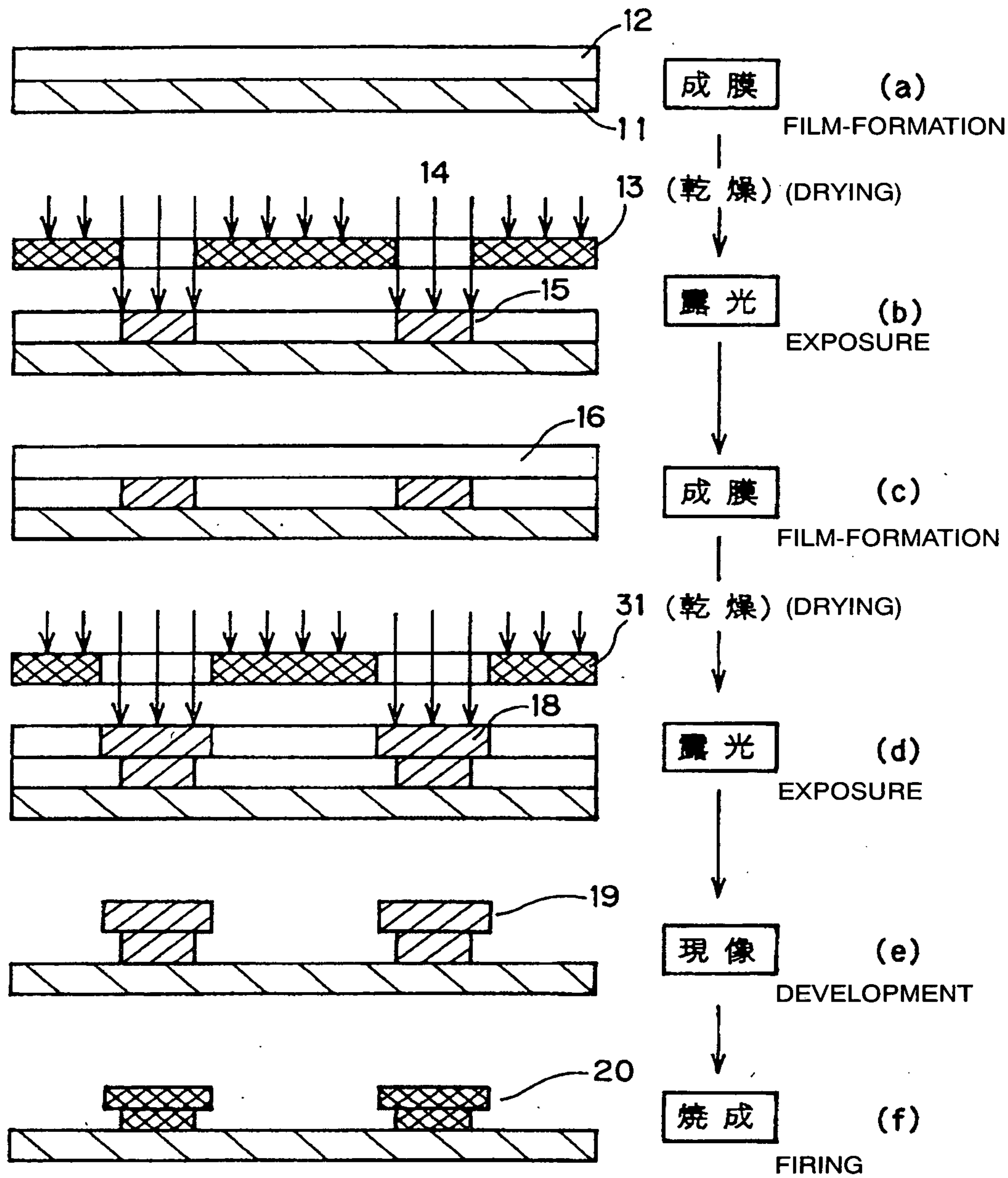
FIRING

【図６】[FIG. 6]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18
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EXPOSURE
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(e)
DEVELOPMENT
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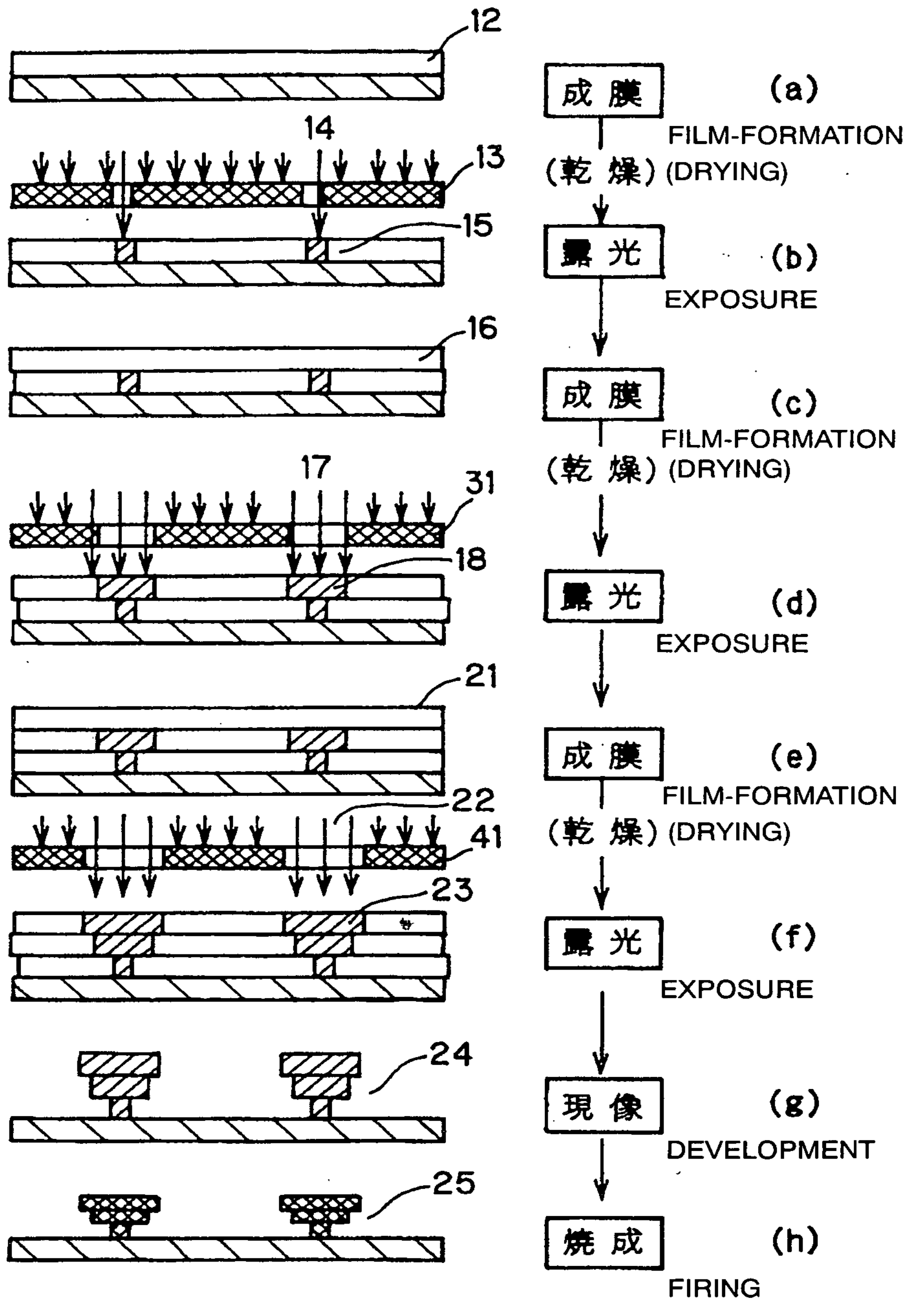
(f)
FIRING

【図７】[FIG. 7]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EXPOSURE
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FILM-FORMATION
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(乾燥) (DRYING)
露光
EXPOSURE
(d)
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FILM-FORMATION
(e)
(乾燥) (DRYING)
露光
EXPOSURE
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FIRING
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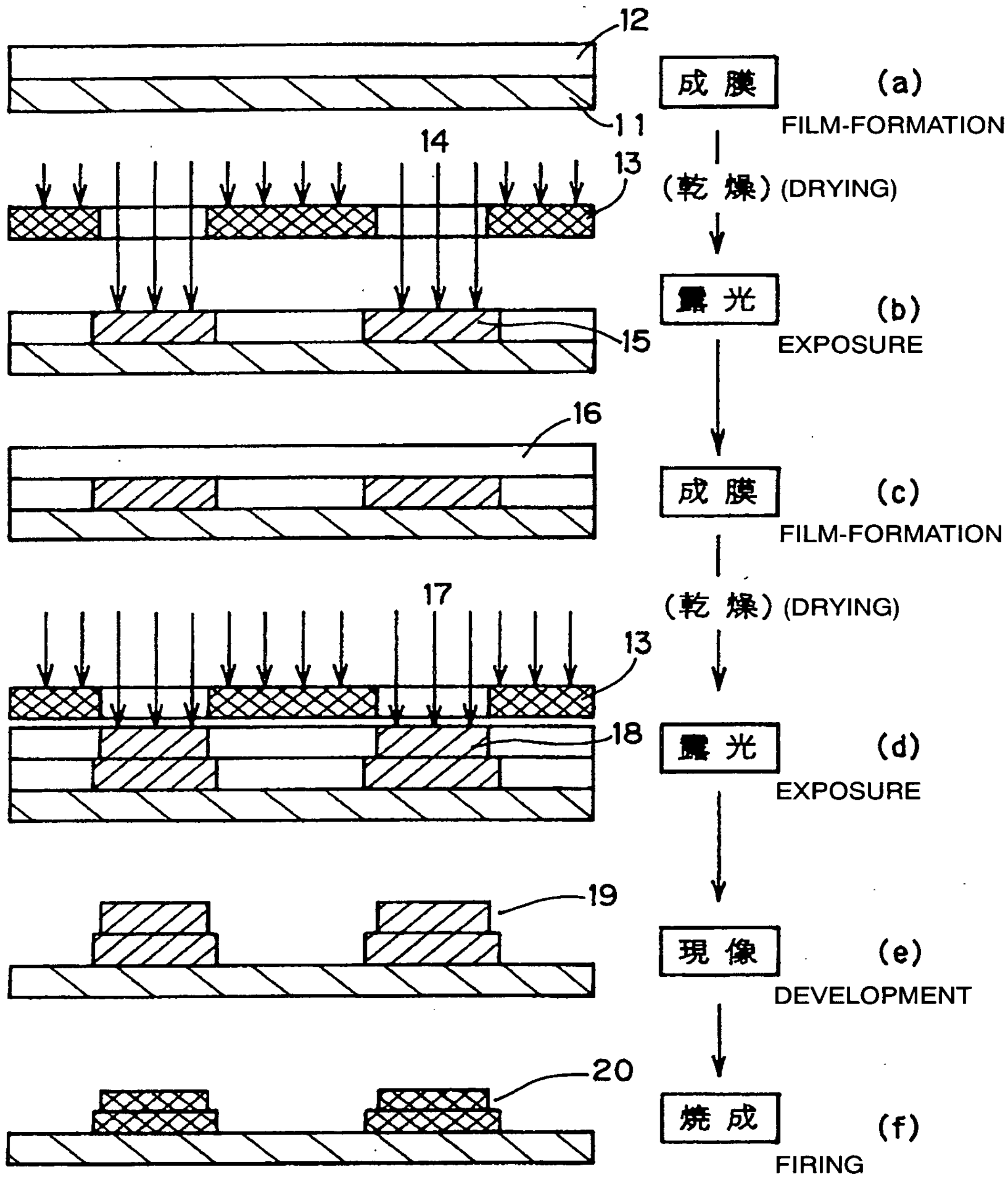
【図８】 [FIG. 8]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FILM-FORMATION
（乾燥）(DRYING)
露光
(d)
EXPOSURE
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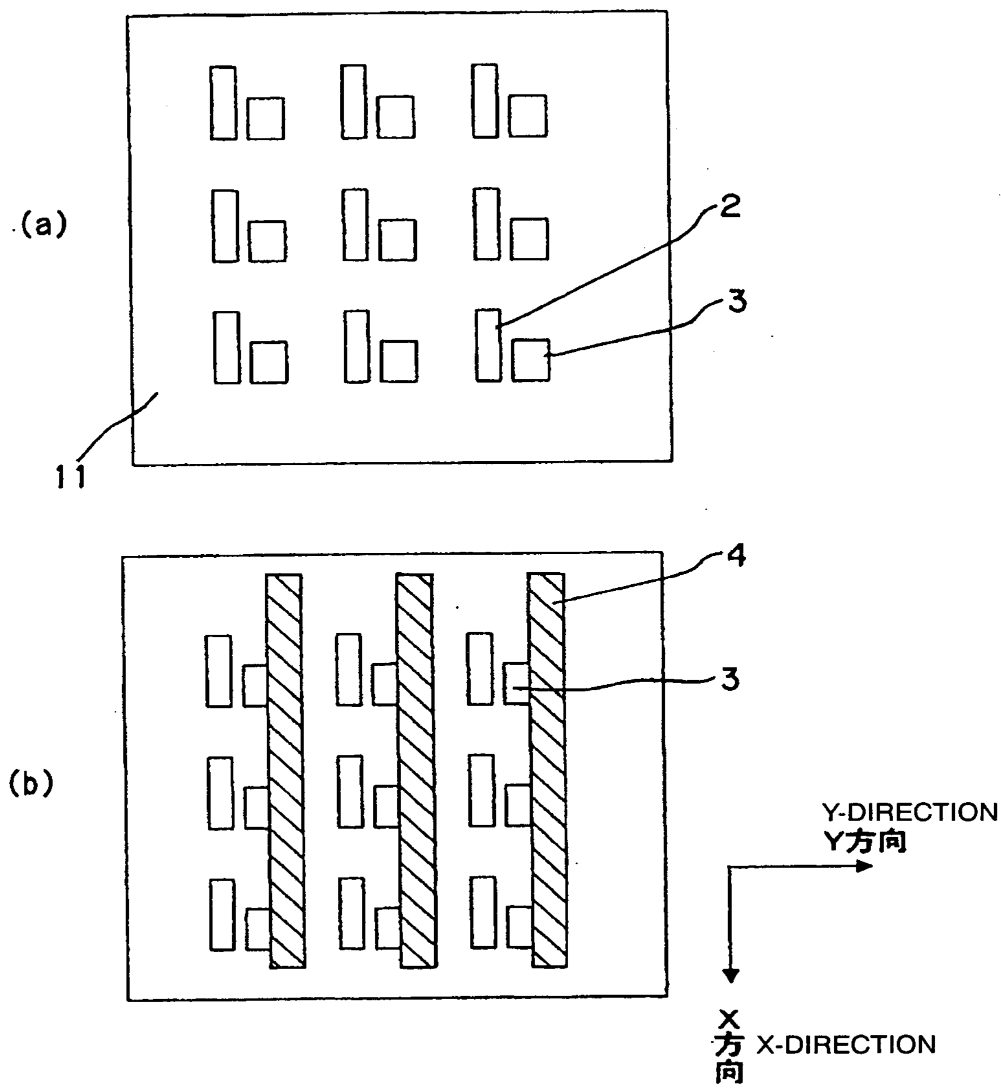
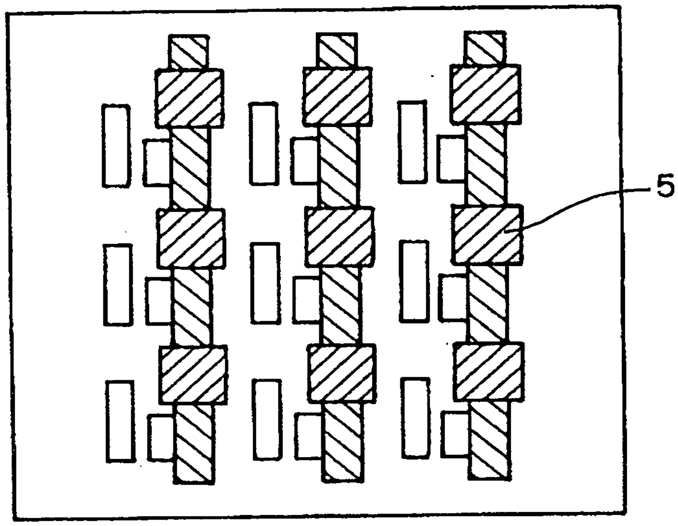
FIRING

【図９】 [FIG. 9]

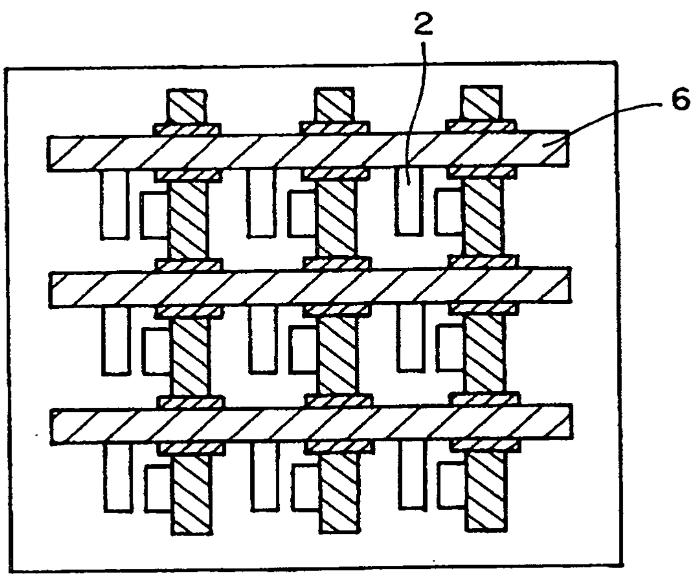


【図１０】[FIG. 10]

(a)

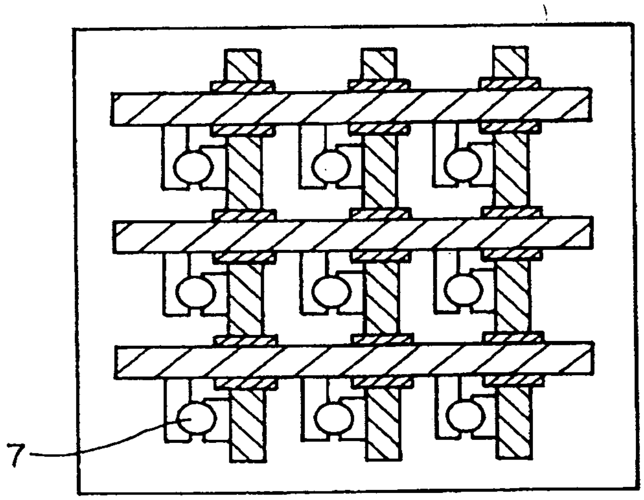


(b)

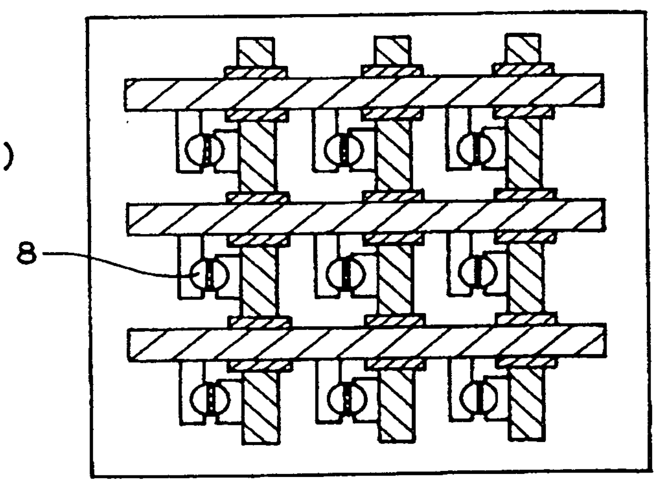


【図１１】[FIG. 11]

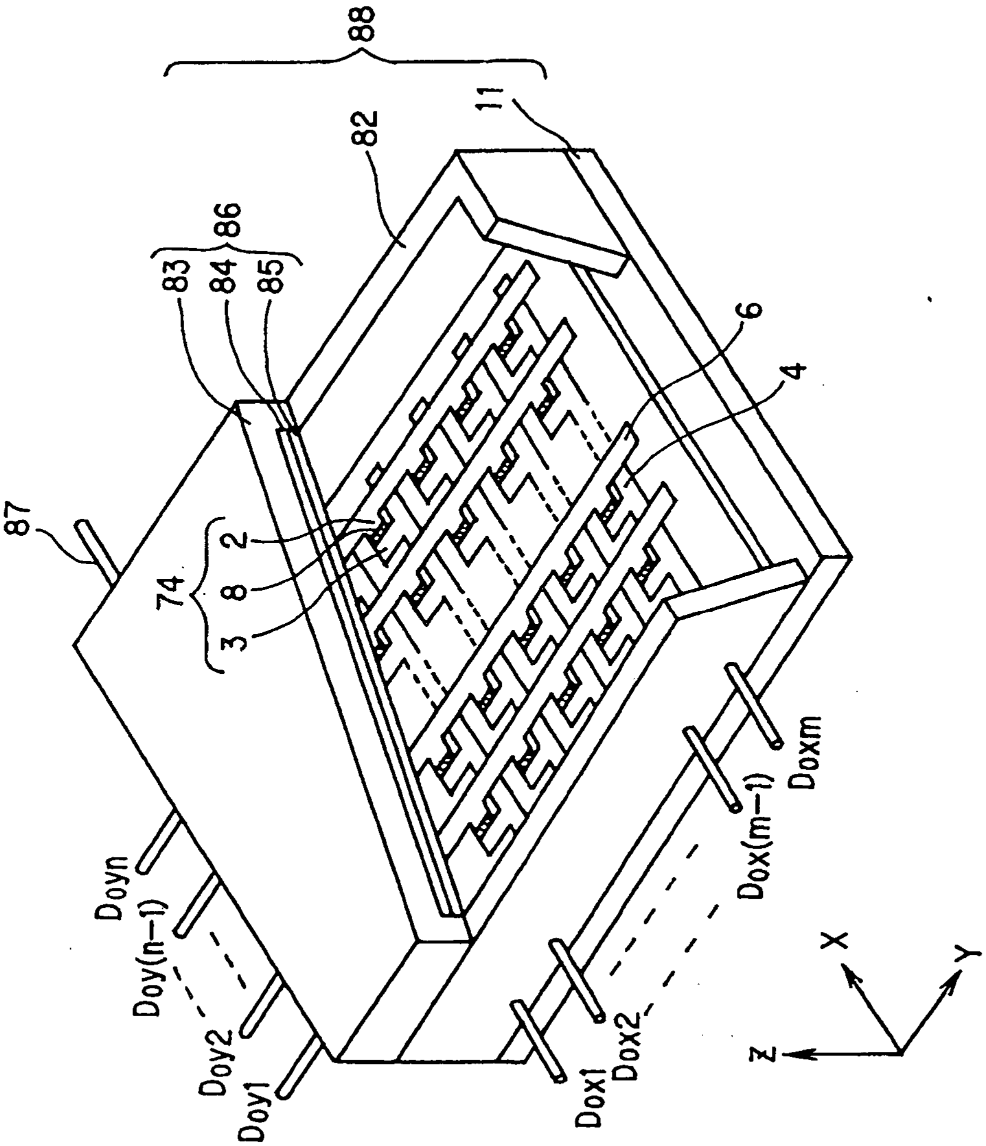
(a)



(b)



【図１２】 [FIG. 12]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8
3
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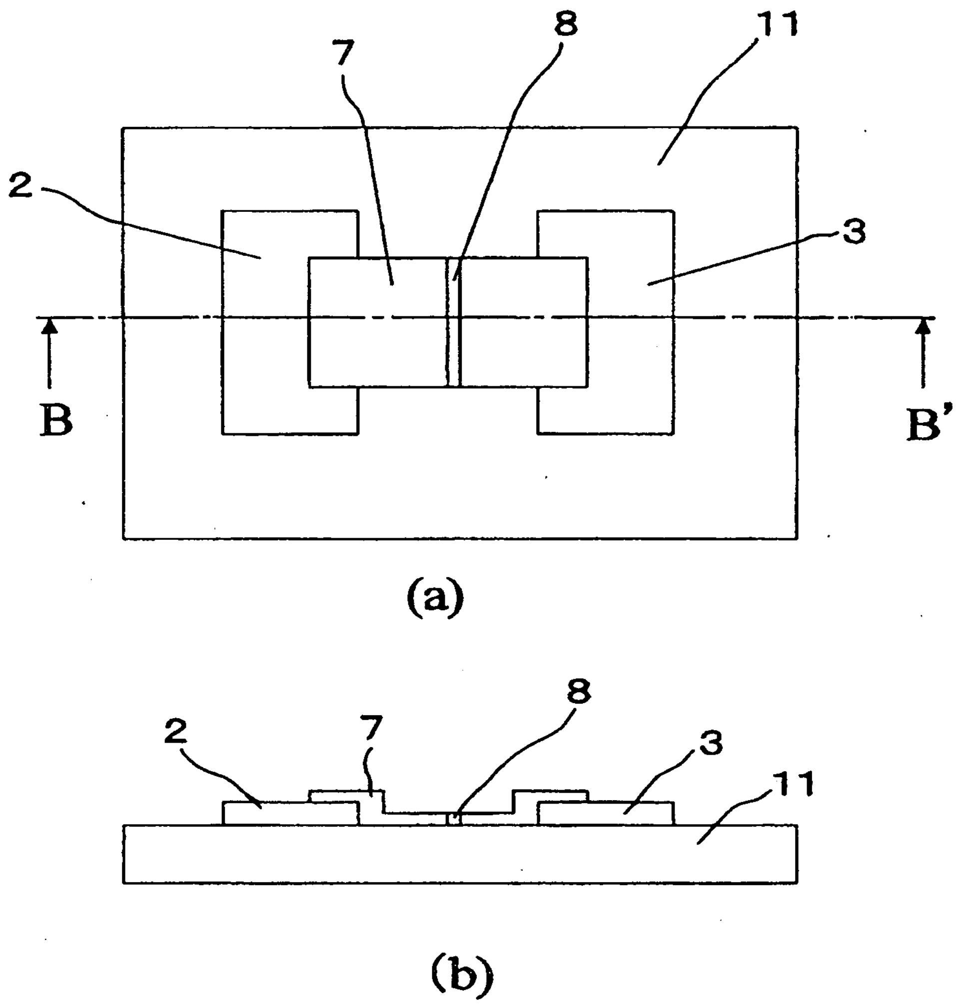
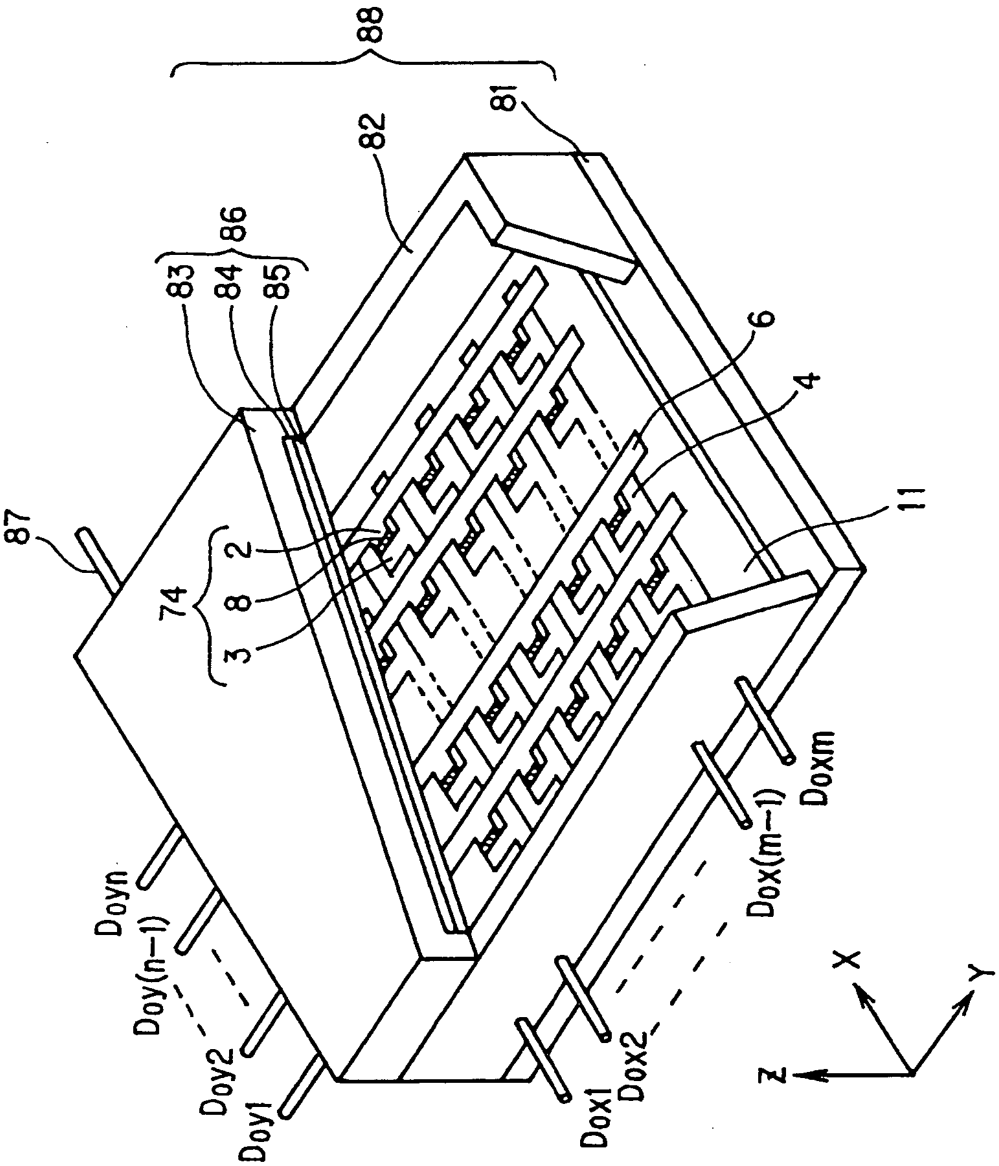
Doy(n−1)
Doy2
Doy1
Dox1
Dox2
Dox(m−1)
Doxm
X
Y
Z

【図１３】[FIG. 13]



【図１４】[FIG. 14]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Dox1
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Dox(m−1)
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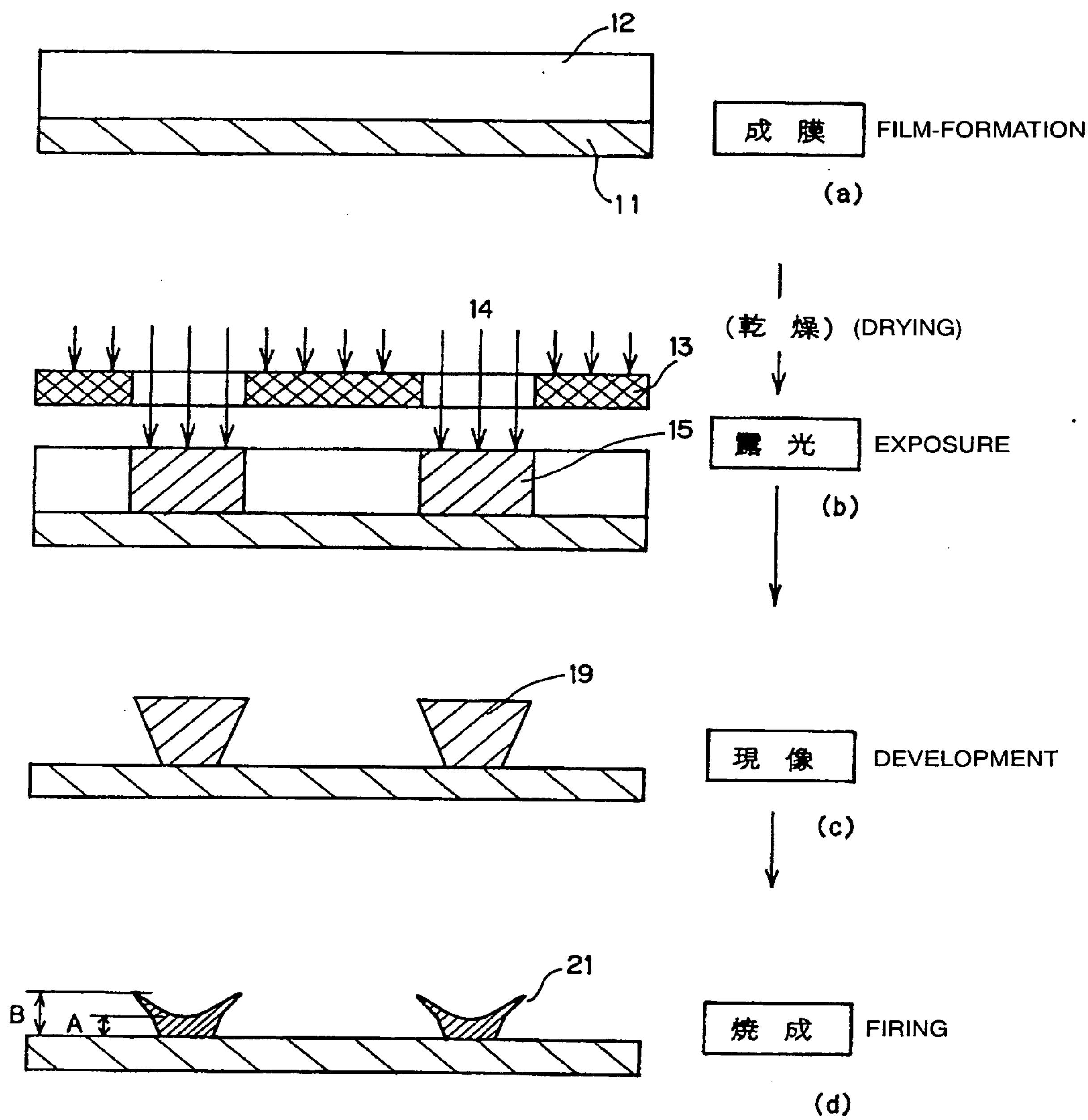
【図１５】[FIG. 15]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[Name of Document] ABSTRACT

[Abstract]

[Object] To provide methods of producing an electroconductive film, a circuit substrate, an electron source, and an image forming apparatus, and the electroconductive film, the circuit substrate, the electron source, and the image forming apparatus.

[Solving Means] Exposure is repeated two times, and in the state, as shown in Fig. 1(a), a developing step is carried out for a photosensitive paste layer having a height of about 13 μm, and thereafter, a baking step is carried out. Thus, a wiring pattern 20 is formed. Thereby, the edge curl of the wiring pattern 20 can be considerably reduced.

[Selected Figure] Fig. 1